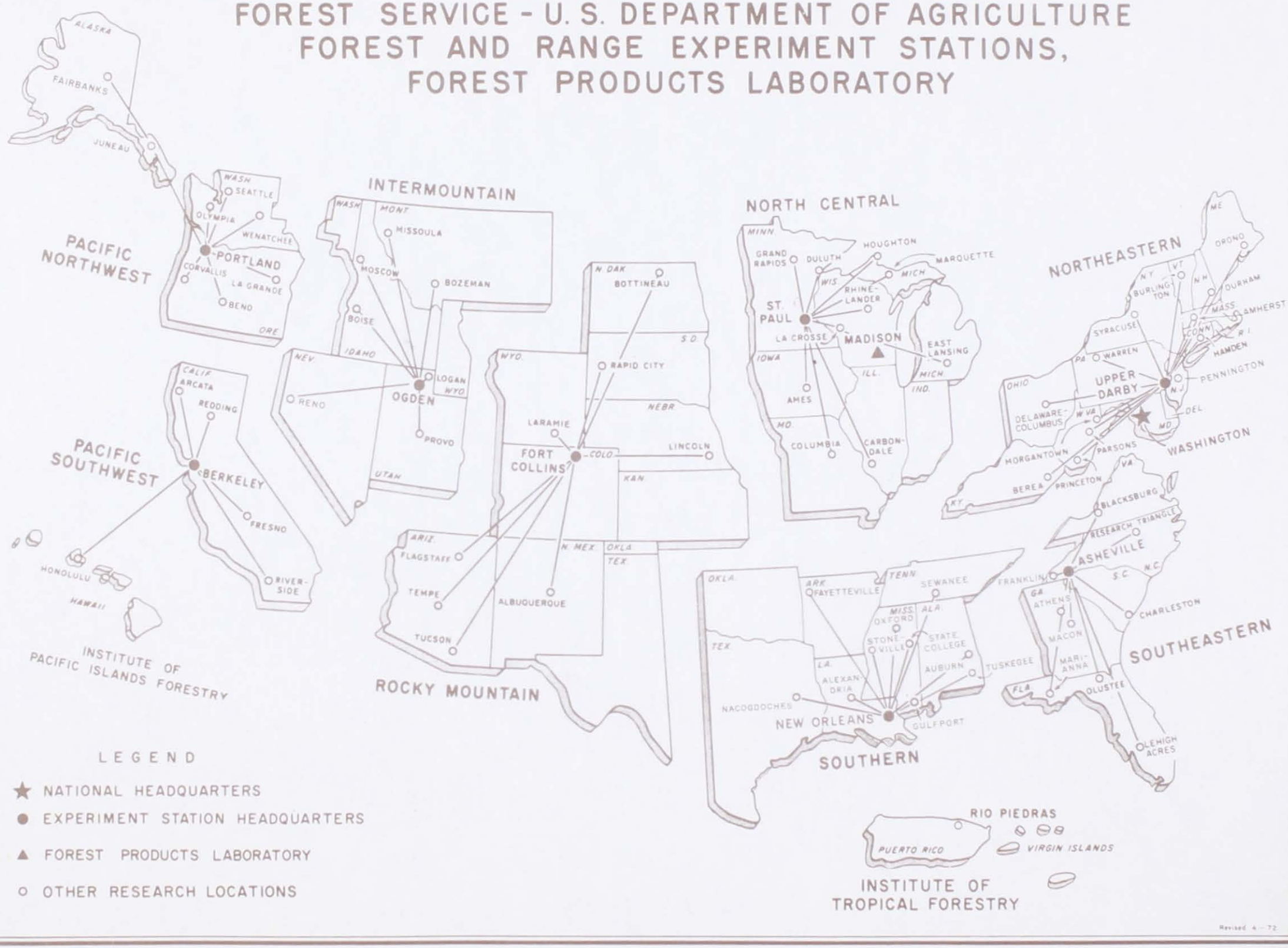
SD11
A3
1972

forest service research accomplishments/1972

LIBRARY
JAN 15 1973
ROCKY MOUNTAIN STATION

UNITED STATES DEPARTMENT OF AGRICULTURE • FOREST SERVICE

FOREST SERVICE - U. S. DEPARTMENT OF AGRICULTURE
FOREST AND RANGE EXPERIMENT STATIONS,
FOREST PRODUCTS LABORATORY



LEGEND

★ NATIONAL HEADQUARTERS

● EXPERIMENT STATION HEADQUARTERS

▲ FOREST PRODUCTS LABORATORY

○ OTHER RESEARCH LOCATIONS

Revised 4-72

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Washington, D. C. 20250

1380 (4000)

Dr. T. K. Cowden
Assistant Secretary
U.S. Department of Agriculture
Washington, D. C. 20250

Dear Dr. Cowden:

As a former researcher, I take particular pleasure in sending you this report of the Forest Service's research accomplishments for 1972.

In addition to reporting the continuing research programs, this report gives evidence of the new approaches the Forest Service is taking in directing its research capabilities toward the critical issues in forest resource management. In keeping with that focus, more attention is also being given to improving the methods of transferring research results to the practitioners and policymakers.

Sincerely,

John R. McGuire

JOHN R. McGUIRE
Chief

Use Pesticides Safely

FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE

NOTICE: The identification and description of commercial products in this publication are solely for information purposes. Endorsement of any commercial product is not intended and must not be inferred. Readers are cautioned to handle all pesticides, herbicides, and fungicides mentioned in this publication strictly in accordance with manufacturer's labels. These chemicals are harmful to people, farm animals, wildlife, and fish, and can contaminate water supplies.

FOREWORD

Forest Service research plans are coordinated through the U.S. Department of Agriculture's Office of Science and Education with research in other USDA agencies, with that conducted under the Hatch Act at land grant institutions, and with that conducted under the McIntire-Stennis Act at schools of forestry. Coordination of research with other educational institutions, private enterprises, nonprofit institutions, and other public agencies is maintained mostly through direct contact between people of these organizations and those of the Forest and Range Experiment Stations. Federal, State, industry, and university cooperation in solving mutual problems is achieved through cooperative agreements that provide for joint development and support of the research by the cooperators.

This report is arranged by research subject areas in order that the reader can go directly to the areas of interest to him. Each accomplishment is summarized in a single, short paragraph followed by an abbreviation denoting the Forest Service research unit best able to supply additional, detailed information and copies of the 1,138 publications listed. Addresses of the research units are given in the Publication List and Index.

December 1972

RESEARCH ACCOMPLISHMENTS - 1972

CONTENTS

	(Research Problem Areas included)	Page
I. Improving the environment		
A. Reducing pollution	(214, 901)	1
1. Controlling soil erosion		1
2. Utilizing solid wastes		1
3. Chemicals in the forest environment		1
4. Noise abatement		2
B. Improving wildlife habitat	(904)	2
1. Evaluating and improving wildlife habitat		2
2. Integrating wildlife and other land uses		3
C. Developing opportunities for outdoor recreation	(902)	4
1. Wilderness ecology and management		4
2. Managing the visual environment		5
3. Socioeconomic values of outdoor recreation		6
4. Campsite design and management		7
5. Analyzing recreation resources and use		8
D. Developing range resources	(112)	9
1. Evaluating range resources		9
2. Characteristics and forage values of range plants		10
3. Livestock and grazing management		10
4. Range ecology		11
5. Range improvements		11
E. Trees to enhance the environment	(905)	12
II. Improving the environment and productivity		
A. Improving environmental quality through fire management	(203)	13
1. Fire prevention, hazard reduction, and prescribed burning		13
2. Fire management methods and systems		14
3. Forest fire science		16
B. Improving insect and disease control	(201, 202)	18
1. Life history and ecology of insects		18
a. Bark beetles		18
b. Defoliators		20
c. Shoot- and tip-feeding insects		20
d. Sucking insects		20
e. Seed and cone insects		21
f. Wood-products and boring insects		22
g. Root and root-collar feeders		23
h. Mathematical models		24
i. Miscellaneous		24

	(Research Problem Areas included)	Page
2. Insect physiology, nutrition, and rearing		25
3. Biological control of insects		28
a. Invertebrate parasites and predators		28
b. Vertebrate predators		29
c. Insect pathogens		29
4. Chemical control of insects		30
a. Insecticides		30
b. Natural products		33
5. Silvicultural and mechanical control of insects		34
6. Host resistance to insects and tree physiology		34
7. Sampling and survey methods		35
8. Forest pest management		37
9. Root diseases		37
a. Annosus root rot		37
b. Poria root rot		38
c. Nematodes		38
d. Mycorrhizae		39
e. Miscellaneous root diseases		39
10. Stem cankers		40
a. White pine blister rust		40
b. Fusiform rust		41
c. Other tree rusts		42
d. Other cankers		42
11. Dwarf mistletoes		42
12. Vascular wilts		43
13. Foliage diseases		44
14. Air pollution damage		45
15. Deterioration of wood		45
16. Forest fungi		46
17. Miscellaneous studies		47
C. Accelerating forest resource surveys	(110)	48
1. Forest inventory		48
2. Timber utilization and production		49
3. Survey techniques		50
D. Economics of forest management	(303, 903)	51
1. Methods of financial evaluation and planning		51
2. Timber growing economics		51
3. Multiple-use economics		52
4. Impacts on on forest industry and regional economies		53
E. Improving engineering systems	(302)	54
F. Improving water quality and yield	(101, 102, 104, 105, 107, 108)	55
1. Improving water yields		55
a. Vegetative manipulation		55
b. Soil and other influences		56
2. Managing watersheds		57
3. Watershed rehabilitation and damage prevention		58

	(Research Problem Areas included)	Page
4. Water quality		58
5. Measuring environmental parameters		59
G. Bettering silvicultural systems	(111)	59
1. Natural regeneration		59
2. Silvicultural methods		62
3. Ecological relationships		64
H. Remote sensing methods	(113)	66
I. Weather modification and weather effects	(109)	67
III. Improving timber productivity and extending supplies		
A. Intensive culture methods	(111)	68
1. Site evaluation and soil improvement		68
2. Artificial regeneration		71
3. Stand improvement		75
4. Animal damage		77
5. Growth requirements		78
6. Growth and yield		81
7. Forest measurements		82
8. Management planning		84
9. Maple syrup production		85
10. Naval stores		85
B. Breeding improved trees	(301)	86
1. Distribution and classification of forest trees		86
2. Inherent variation		86
3. Insect-disease resistance		88
4. Tree breeding methodology		89
C. Improving use of wood	(401)	90
1. Wood and timber quality		90
2. Wood products and wood processing		93
3. Wood chemistry and fiber products		96
4. Wood engineering		98
5. Miscellaneous		100
D. Marketing under-used species and residues	(502)	100
E. Supply, demand, and price analysis	(513)	101
Publication list and index		103

I. IMPROVING THE ENVIRONMENT

A. Reducing Pollution

1. CONTROLLING SOIL EROSION

1. Terraces were found to effectively control runoff and erosion on highly erodible surface-mine benches in Breathitt County, Kentucky. Where the spoil was predominantly shale, peak floes on a terraced plot averaged 65 percent less than those on the control plot, sediment yield average 52 percent less, and total runoff average 42 percent less. Comparable figures for plots having substantial amounts of sandstone were 65, 70, and 6 percent, respectively. NE (184).

2. Slope was the principal factor contributing to soil slip erosion on mountainous watersheds in southern California, but conversion of brush to grass produced 2.8 times more erosion. In evaluating conversion of brush to grass on steep terrain, the potential hazard of increased erosion should be considered. PSW (194).

(For additional items relating to IA1 see paragraphs 365, 366, 373, 378-382.)

2. UTILIZING SOLID WASTES

3. Salty bark residues from wood industries of the Pacific States generally did not adversely affect soil microbes, and were only somewhat depressive to growth of salt sensitive plants at higher concentrations when mixed into the soil. Much of the 5 million tons of tree bark produced annually contains up to 3.5 percent salt (NaCl) as a result of exposure to sea water, but could be used for surface mulching for some salt tolerant plants. PNW (195).

3. CHEMICALS IN THE FOREST ENVIRONMENT

4. Endrin was applied to soil at rates of more than three times the maximum normally used in treating tree seed in the Douglas-fir region of the Pacific Northwest without exerting an appreciable effect on numbers of soil microbes or on ammonification, nitrification, or sulfur oxidation. Rate of decomposition of soil organic matter, as indicated by the production of CO_2, increased significantly in the presence of endrin. The relatively insignificant amount of endrin formulation entering forest soils from coated seed is believed unlikely to damage soil microbes and their activities. PNW (196).

5. Forest tree thinning workers were found to absorb arsenic from the silvicides cacodylic acid (dimethylarsinic acid) and monosodium methanearsonate (MSMA), which are used by public and private forest agencies in chemical tree thinning programs throughout the Pacific Northwest and elsewhere in the United States. Much of the chemical appears to be excreted from the body in a short time, and no evidence of continuing increase in arsenic levels over a period of more than 2 months was found. However, persons using these materials should be trained to observe all necessary precautions to minimize their exposure. PNW (207).

4. NOISE ABATEMENT

6. Our environment has become relatively noisy in many areas as a result of increasing population density and heavy dependence on mechanical devices. Forest stands in the northeastern United States were found to absorb sound at the rate of 6 to 8 decibels per 100 feet, although the actual amounts depend upon vegetation density and sound characteristics. Even though the amounts of absorption seem low, trees and associated vegetation may make the difference between a livable and nonlivable environment. NE (208, 209).

B. Improving Wildlife Habitat

1. EVALUATING AND IMPROVING WILDLIFE HABITAT

7. Deer and elk have marked seasonal preferences for certain forest habitats in Oregon. The animals feed in both grasslands and open forests during the spring, but later shift to forest habitats for food and cover as preferred forbs mature. Open forest has the greatest season-long abundance of forage, while dense forest is more important for providing cover than food. PNW (310).

8. Two dimensional phenolic extraction on chromatographic paper was discovered to be a simple and accurate method for classifying the foliage of various plant strains of big sagebrush into major palatability classes. The results of the technique were in close agreement with observed preferences by deer. The strong association between chromatographic variation and palatability suggests that this procedure may be utilized to quickly evaluate the grazing potential of any collection of big sagebrush foliage samples. INT (312).

9. Proper management of elk herds depends in part upon our knowledge of the nutritional values of foods available during the winter months when the animals are often under nutritional stress. Of 11 herbs and shrubs tested from winter elk feeding sites in Wyoming, big sagbrush had the highest digestibility. The high digestibility plus the fact that winter use by elk is less damaging to the plant than use at other times of the year suggest that big sagebrush may be an important winter elk food. RM (315).

10. The study of food habits is a major research activity in wildlife ecology, and many workers have used tame animals to acquire more exact information on food preferences. The most acceptable results for tame Rocky Mountain mule deer are obtained if the fawn is left with its mother for at least 12 hours but less than 24 hours. This time period allows the fawn the nutritional benefits of its mother's milk but exposes the fawn to the trainer before developing a fear of humans. RM (314).

11. An illustrated "Atlas of Southern Forest Game" has been published by the Southern Forest Experiment Station. The Atlas presents information on numbers, distribution, and hunter harvest of the principal game animals of our southern forests. The Atlas should prove helpful and informative to researchers, game managers, and outdoor recreationists interested in wildlife and their habitats in the South. SO (311).

12. Studies of porcupine populations are hampered by the fact that the longevity of porcupines under wild conditions has never been well established. This is because there is no proven method for aging the animals. Recovery of porcupines captured and ear-marked in 1961 in western Upper Michigan, indicates the animals have a lifespan of at least 10 years. NC (309).

13. White-tailed deer in the Appalachian Mountain, Piedmont, and Coastal Plain Provinces of the Southeast select the same type of diet seasonally although foraging in ecologically different areas. Green leaves of woody plants were the most important single item selected by deer, ranking first in frequency of occurrence and volume. The annual contribution of forbs, grasses and sedges, fungi and dried leaves combined equalled that of green leaves. Hardened woody twigs had the lowest frequency of occurrence and lowest volume of all food categories. SE (313).

(For an additional item relating to IB1 see paragraph 383.)

2. INTEGRATING WILDLIFE AND OTHER USES

14. Mixed conifer stands in the Pacific Northwest that have been clearcut, planted with pine trees, and seeded to timothy are a source of summer forage for elk, deer, and cattle. After five seasons use, growth and survival of the trees had been neither greatly harmed nor benefited by the grazing animals. PNW (318).

15. Wildlife food plants in clear-cut oak stands in the Ozarks increased severalfold compared with production in stands selectively cut. Fruit production in clear-cut stands was substantially lower than that in selectively cut stands because of the absence of overstory vegetation. This suggests that forest management needs to disperse clear-cuts in mature stands to promote maximum benefits to wildlife habitat. NC (316, 317).

16. Dependable information on changing squirrel populations is essential to effectively manage their habitat. A study of census methods showed that squirrel population trends on a 20,000-acre tract in West Virginia were measured best by personal hunter interviews to determine hunter success. Use of this information can reduce costs and improve reliability of squirrel habitat management evaluation on large forest units. NE (320).

17. The food habits of the bobwhite quail have been researched rather extensively throughout the Southeast, but little is known about the seasonal diet in the flatwoods of south Georgia and north Florida. Actually, quail diets in grazed flatwoods of south Georgia are not greatly different from those reported in other regions. Quail rely heavily on seeds of plants commonly associated with fire or mechanical site disturbance. Cultivated grains such as corn are relished by quail. SE (319).

C. Developing Opportunities for Outdoor Recreation

18. A symposium on recreation was held in October 1971 designed to consolidate and synthesize past research in forest recreation. The papers in the proceedings cover a wide range of recreation subject matter, and are aimed at meeting the needs of the planner and manager in both private and public areas of forest recreation. At the same time, each paper includes a wealth of reference material that should be helpful to anyone who wishes to pursue a given subject in more depth. NE (164).

1. WILDERNESS ECOLOGY AND MANAGEMENT

19. Wilderness managers have needed a technique to develop accurate descriptions of the natural ecosystem to guide management. A technique called systems analysis and modeling has been used to describe the wilderness ecosystem of the Boundary Waters Canoe Area in northern Minnesota. It identifies and describes the communities of the area and shows how they are related to the environment and to each other; predicts the behavior of species along environmental gradients; and predicts interspecific association patterns. NC (135, 136).

20. A pollen diagram providing an absolute time-scale documentation of vegetation changes was prepared for Lake of the Clouds region in the Boundary Waters Canoe Area of Minnesota. Cores to get pollen samples were taken to a depth of 100 feet below the water. Carbon-14 dating demonstrated that layering in the cores was annual. The 9,349 annual layers in the 100-foot cores provide a continuous record, in absolute time, describing post glacial vegetation changes. NC (132).

21. Canoeists rely heavily on outfitters for information on the Boundary Waters Canoe Area. The information provided by outfitters is important in generating support or opposition by the users for existing or proposed management policies. Utilization of the outfitter-camper influence process could increase public understanding of the wilderness and its management. NC (133).

22. Minnesota's Boundary Waters Canoe Area is one of the most heavily used wilderness areas in the United States. To describe the impacts of increasing use on established recreation sites, area expansion, soil loss and compaction, declining tree vigor, loss of ground cover, and increased use were quantified as indicators of site deterioration. By combining these factors with amount of use and cover type, it may now be possible to develop a deterioration stage classification useful to managers. NC (134).

23. Contrary to common thinking, wilderness users are not exceptionally wealthy nor do wilderness visitors have more leisure time than most people. Wilderness, as viewed by the users, is not separate from or in contradiction with multiple use, and wilderness must be managed in order to optimize net benefits to society. INT (137).

24. Biological changes in a wilderness ecosystem due to recreational use necessitates the knowledge of how visitors themselves define excessive change or inappropriate use. Visitors to four wildernesses indicated that solitude (or low intensity of use) was an important quality of wilderness, and that littering and the visible effects of overuse or misuse were more objectionable than encounters with other visitors. A substantial proportion of the visitors seemed to have attitudes and desires that would be more suitable for roadless recreation areas than by wilderness. INT (138).

2. MANAGING THE VISUAL ENVIRONMENT

25. A study of viewer preferences found that nature scenes were greatly preferred to urban scenes. Viewers responded most favorably to scenes they could comprehend easily, scenes that promise additional information, and a variety of particular features of the landscape, such as water and paths. NC (139).

26. Dividing a regional landscape into units greatly eases the development of management goals consistent with the visual resource. This approach was evaluated in California where the Lake Tahoe Basin was divided into 11 visual landscape subdivisions. By defining visual subunits, the planners were able to objectively explore the potential scenic impacts of development and establish priorities concerning the directions of development. PSW (140).

27. Multiple forest covers can be managed in naturalistic intergrated patterns that create variety and enhance scenic quality. Three vegetation types build variety: meadow, shrub thicket, and forest. Where they come together they form natural meandering edges and graceful patterns. Land manipulations, including prescribed burning, are scenically compatible if resulting patterns imitate nature. SE (141).

28. Forest management to maintain or improve scenic quality has impact on other forest management goals. This effect was studied

by applying a scenic classification system to a 16-mile strip of highway on the Sierra National Forest in California. By conducting a scenic classification instead of relying on arbitrary rules for protection of scenery, management can be prescribed for each scenic category and management costs estimated. PSW (142).

3. SOCIOECONOMIC VALUES OF OUTDOOR RECREATION

29. In a study to evaluate the effectiveness of various antilitter procedures in two neighborhood theaters, it was found that providing monetary incentives for the appropriate deposit of litter was the most effective method. The incentive procedures resulted in the removal of 90 percent of all litter by the children in attendance. The results of this study suggest the possible utility of employing positive procedures to combat litter in other areas such as campgrounds. PNW (143).

30. Vandalism, nuisance behavior, littering, and violations of rules and regulations are major recreation management problems. Violations occur because of ignorance of, lack of understanding of, or a willingness to disregard rules. Several logical approaches are suggested for the control of depreciative acts, including better communication of rules, education programs to increase the campers awareness of the consequences of certain acts, and stricter enforcement of regulations. PNW (144).

31. Campers and campground managers subscribe to similar goals associated with camping, but they disagree about the types of activities appropriate to attaining those goals. Managers see isolation and primitive interaction with the environment as necessary; users apparently find the highly developed, structured setting of the modern campground and its associated social environment as appropriate. If the campers' perspective is the product of increasing urbanization, then a continued reflection of this influence in the modern camping scene is expected. Strategic location of a range of camping facilities will help avert problems inherent in continued change. PNW (145).

32. Expenditures by campers and other tourists are thought to be an important source of income for rural economics. In a study of families camping in New Hampshire State Parks, total expenditures by the campers varied widely by geographic location and by whether or not the park visit was a major destination or a transient stopover. Camper expenditure patterns suggest that the single goal of maximizing local area economy is a poor rationale for locating new public camping facilities. NE (146).

33. Thirty-four campgrounds on the Superior National Forest in Minnesota were used over five times as much as were others in the same area. Occupancy was related to three factors: proportion of waterfront campsites, length of time the campground had been open, and the fishing reputation of nearby lakes. Onsite interviews identified the factors affecting campground selection as: (1) fishing opportunities, (2) natural setting

(remote, wildernesslike), (3) nearness to recreation attractions (other lakes, streams), (4) recommendations of acquaintances, and (5) availability of water-oriented campsites. NC (147).

34. Rural landowners can make a profit by providing needed snowmobile services and facilities. Case studies of eight commercial snowmobile enterprises in New York indicate that a market is developing, but it is quite restricted and a potential operator should not go into the business without giving careful consideration to the capital and land requirements. NE (148).

35. Northeastern camping market during 1961 to 1967 shifted from a predominantly public-sector market to a commercial-sector market. Growth in both the commercial and the public market was positively related to proximity to water resources. Public camping market growth was associated with unsettled, heavily forested, mountainous zones, while commercial growth was associated with relatively settled, less heavily forested zones. Growth trends indicate the market will grow at a slower rate in the future. NE (149).

36. Private land leasing could play a major role in alleviating the recreation resource shortage. A study of groups and individuals leasing land for recreation in New York showed that leasing benefits both the lessee and the lessor. The lessee gains access to resources to satisfy his recreation needs, and the lessor is provided an income to help cover his taxes and assist in land conservation practices. NE (150).

4. CAMPSITE DESIGN AND MANAGEMENT

37. The deterioration of ground cover vegetation is a problem on heavily used recreation sites. In drier regions of the West, watering, fertilizing, and seeding increases ground cover on sites under an aspen overstory. On sites under coniferous stands, herbaceous ground cover cannot be established and maintained even after water, fertilizer, and seed are applied. INT (151).

38. Small, unballed tree and shrub seedlings were planted in a developed campground in the southern Appalachians to determine the suitability of supplementing existing vegetation with small planting stock. Seedling loss was high and height growth was poor, primarily because of vegetative competition and maintenance activities. SE (152).

39. Vegetation on 49 Adirondack campsites was mapped and measured in 1964 and again in 1969. Results indicate that vegetation on established, well-maintained campsites deteriorates little, even though the sites receive heavy, sustained recreation pressure. NE (153).

5. ANALYZING RECREATION RESOURCES AND USE

40. Often a method is needed to predict total visits using counts of past per-capita and total visits. While it is convenient to do this simply on the basis of the correlation coefficient printed by most regression programs, this easy procedure may produce erroneous results. It is better for the researcher to use several alternative error measures to compare the prediction models. PSW (154).

41. Among all industries in the business of outdoor recreation, ski resort owners have one of the largest capital investments. And yet few, if any, prediction equations based on the economy of the operation have been devised to help them forecast the use of a proposed resort. An approach has been developed which allows the investigator to forecast the econonomics of the operation by the level of use a proposed site would receive and to identify the public it would be serving. PSW (155).

42. A new computerized technique called VIEWIT for measuring the terrain visible from a given point was applied on the Black Hills National Forest, South Dakota. The areas seen from 12 heavily visited scenic points and along three proposed routes for a scenic tramway were delineated. The computer produced overlay maps that show the maximum area visible from each observation point. PSW (156).

43. Campground registration permits contain information useful to planning and specifically helpful in determining the market areas which campgrounds are serving. It is difficult, however, for managers and planners to reduce the voluminous information into useful summaries. A computerized method is now available for a quick and inexpensive summarization of point-of-origin and length-of-stay data for campground users. The method should be equally useful for public as well as private campgrounds. PSW (157).

44. Current sampling techniques for estimating recreation on land have little direct application for estimating water-based recreation use. A sampling method for estimating recreation use on large bodies of water has been developed and tested in eastern Oregon. The method utilizes data on hours of boating per person per trip, the number of persons per boat, and the number of boats per hour, and applies a simple linear regression analysis. Study results show the method provides suitably precise estimates of recreation use at a reasonably low cost. SE (161).

45. A sampling technique for estimating fishing use was pilot tested on a small trout stream on the Francis Marion National Forest in South Carolina. Utilizing a short questionnaire completed by fishermen using the stream, the technique provided precise low-cost estimates of fishing use. SE (160).

46. Surveys of wilderness visitors are valuable in wilderness management, but improved sampling methods are needed. Sampling methods involving unmanned registration stations and personal interviews of entering

groups provide the most precise estimates of wilderness use. Mail surveys are less expensive than personal interviews but lack control of sampling as with the unmanned registration stations causing incomplete coverage of the user population. Nevertheless, a registration system is worthwhile as one of the tools for wilderness-use estimation. SE (159); INT (162, 163).

47. Outdoor recreation activities are numerous and diverse which hampers their study. A study categorizing by types of five conceptually related outdoor recreation activities was developed for more meaningful analysis of outdoor recreation activities which are too numerous to consider separately. Methodological problems are discussed and theoretical models of relationships between activities and biological and social factors are proposed for future testing. PNW (158).

48. The public encounters more environmental blights driving than in any other pursuit. The development of inventory methods to measure the kind and extent of manmade alterations on the roadside landscape is the first step towards the reduction of scenic conflicts along roadways. Ground surveillance and ground photography are used effectively to record impacts within the corridor visible from the road. Aerial photography can be relied on for recording impacts on a more complete corridor including areas screened from the road by vegetation. PNW (165).

49. Statistically reliable methods exist for estimating recreation use on large areas, but they often prove prohibitively expensive. Two measures relating to recreation use which have not been stressed but which can be important to planners and managers concern the number of participants engaging in specific activities and the length of time given to these activities. These use-related measures can be employed to yield better estimates of visitor-days than purely subjective means, though not on a statistical basis. SE (166).

D. Developing Range Resources

1. EVALUATING RANGE RESOURCES

50. A system of color aerial photography and ground sampling has promising possibilities for conducting range inventories at less cost than conventional ground surveys. Large-scale color infrared aerial photographs can be used effectively to identify various shrub species and certain large forbs. Green herbage or corresponding dry weight mass can also be estimated reliably using color infrared aerial photographs. The efficiency of color infrared photos depends on obtaining photographs at the right time of the year in respect to phenology of the vegetation. RM (168, 169).

(For an additional item relating to ID1 see paragraph 380.)

2. CHARACTERISTICS AND FORAGE VALUES OF RANGE PLANTS

51. Arizona cottontop is a productive, palatable, dominant perennial grass on many southwestern semidesert ranges, but basic information has been lacking on its growth and development. This information is now available from detailed studies under natural field conditions and will be valuable for the development of management practices to use Arizona cottontop more widely in revegetation work, and for the management of the grass in native stands. RM (170).

52. Direct seedings of winterfat, a naturally occurring common shrub on semiarid ranges of New Mexico and very palatable to livestock and wildlife, have often resulted in poor stands or complete failures. Studies now show that germination and emergence of direct seeding are best with temperatures for germination between 50 to 80 degrees F. and a planting depth of 1/16-inch in moist but not excessively wet soil. This information is valuable when using this shrub for revegetating semiard ranges. RM (172, 173).

53. Sheep weight gains and grazing capacity of spring growth of cheatgrass were equally as good as those for native bunchgrasses in southern Idaho during wet years. However, during dry years, larger weight gains, greater grazing capacity, and higher gains per acre were realized from bunchgrasses. Therefore, bunchgrasses with their extended green-feed periods and higher productivity during dry years promise greater overall gains and grazing capacities than cheatgrass. INT (171).

3. LIVESTOCK AND GRAZING MANAGEMENT

54. Clearcutting of lodgepole pine in Montana stimulates increased production of the understory vegetation for big game and livestock. Seeding of forage species in the clearcuts substantially adds to the production. To take advantage of this increased resource, big game and livestock habitat managers have needed a method to predict production before clearcutting. Site index, a method commonly used to measure site potential for lodgepole pine growth, was evaluated as a possible method to predict understory production but failed to provide the necessary capability. INT (167, 174).

55. Southern Forest Experiment Station research results indicate that light or moderate grazing by cattle (33 and 37 percent use) does not affect establishment of planted or seeded slash pine or survival to age 5 years. Grazing had no effect on height growth of the pines to age 5. Consequently, grazing can be effectively integrated with timber production on slash pine forest lands in Louisiana. SO (176).

56. Cattle producers using the 50 million acres of commercial forest land in the West Gulf of Mexico region have needed published guides summarizing research results concerning management of the beef cow herds grazing these native ranges. This need is met by an analysis of past

research conducted on the Palustris Experimental Forest in central Louisiana. It describes prescribed rotational burning, supplemental feeding of cottonseed cake, crossbred cows, good bulls, regulated breeding seasons, and use for maximum returns of forest range investments. SO (175).

57. The subalpine zone of the Big Horn Mountains, Wyoming, is characterized by grassland parks rimmed by coniferous forests. These grasslands, together with associated meadows and shrublands, occupy one-third to one-half the 1.1 million acres within the Big Horn National Forest and are an important range resource highly prized by local stockmen. Twenty years of cooperative range research have now been summarized in the form of management guides for livestock ranges on the Big Horn Mountains and similar rangelands of the West. The report summarizes information on geology, climate, soils, and vegetation, and discusses grazing systems and range improvement practices. RM (177).

4. RANGE ECOLOGY

58. Botanists, resource managers, and others interested in the vegetation of the Black Hills of South Dakota and Wyoming now have available a revised checklist of the vascular plants of the region. The checklist gives the scientific name, botanical authority, plant family, and a life form designation for 1,759 plant taxa of the Black Hills. Also included is a discussion of the physiography and plant ecology of the area. RM (178).

5. RANGE IMPROVEMENTS

59. Growth response to application of all combinations of nitrogen (N), phosphorus (P), and sulfur (S) on four forest and three grassland soils in northeastern Oregon showed that a significant N-S interaction existed for all seven soils. For two grassland soils, a significant response to P was obtained in combination with N and S. The volcanic-ash derived soils have high yield responses to fertilization. PNW (179).

60. In a 25-year-old plantation of slash pine near Olustee, Florida, a single application of 200 pounds of nitrogen and 44 pounds of phosphorus per acre increased production of herbaceous understory to more than a ton per acre the first year, a fivefold increase. This indicates that with fertilization, a plantation suitably stocked for timber production can also be managed to produce a significant amount of forage. SE (180).

61. The most effective way to stabilize soils in a critical area is to establish plants quickly. The results of studies at Santa Fe, New Mexico, indicate that planting seeds in moist soil and applying a mulch provide near-optimum temperatures and moisture for germination. Mulching results in more moisture in the seed zone. Mulches with reflective properties have proven most effective for seeds that require relatively cool temperatures for germination. RM (181).

E. Trees to Enhance the Environment

62. Lobelia inflata L., Indian tobacco, is the main source of the alkaloid, lobeline, which is used in antismoking preparations. To aid the drug-plant buyer in determining the purity of purchased L. inflata seed, the comparative description of the seeds of L. inflata and three common lobelias of Appalachia which are not valuable has been developed. NE (965).

63. Guides for eastern Kentucky and southeastern Ohio are now available for the proper selection of white pine seed sources for Christmas trees. When white pine trees from 16 different seed sources collected in their natural range were grown for 5 years in Kentucky and Ohio, the trees of best Christmas tree quality in terms of color, form, needle length, needle retention, and growth rate came from the Appalachian Mountain region and from lower Michigan. With these proper seed sources, more profitable Christmas tree farms can be established in Kentucky and Ohio. NE (967).

64. The full value of Scots pine as a tree for the Plains has been largely overlooked because performance has been judged on relatively few and mostly unknown seed origins. An 8-year test of 36 rangewide provenances grown in eastern Nebraska showed that selected southern seed sources, with their slow growth, but dark green shoot needles make desirable Christmas trees. The very fast growth and longer needle sources of Central Europe make them useful for windbreaks, while the very yellow northern origins make attractive ornaments in the Great Plains. RM (966).

65. Because the larches combine such desirable windbreak tree characteristics as good height potential, rapid growth, moderate density, and resistance to winter desiccation, they would be a useful tree for the shelterbelt programs in the northern Great Plains. A 10-year test of 3 Siberian, 1 Dahurian, and 2 hybrid larch seed origins suggests that two of the Siberian sources from Tuvinskaya and Altaiskaya mountain provinces should be considered suitable as a seed source for future windbreak plantings. RM (964).

66. Excessive traffic noise, a form of environmental pollution, is increasing in the United States. Tests in Nebraska have now demonstrated that when properly used, trees and shrubs can be an effective means for reducing noise levels. With a wide belt of tall dense trees, noise levels can be reduced by as much as 50 percent, and even a single row of dense shrubs backed by a row of taller trees can effectively reduce noise by 30 percent. Trees, to be an effective barrier to noise, should be placed close to the area to be protected. RM (963).

(For an additional item relating to I E see paragraph 6.)

II. IMPROVING THE ENVIRONMENT AND PRODUCTIVITY

A. Improving Environmental Quality Through Fire Management

1. FIRE PREVENTION, HAZARD REDUCTION, AND PRESCRIBED BURNING

67. Individuals and employers held responsible for starting forest fires in National Forests of the Intermountain and California Regions over a 10-year period were usually local people and respected members of the community. When payments were made, individuals and employers generally paid damages less than those assessed. PSW (325).

68. The diffusion of information in an area of high incendiary forest fire incidence in the southern United States was identified in terms of three distinctly different local opinion leader roles: initiator, legitimizer, and diffuser. Knowledge of the identity of those who play each role should be a benefit to organizations conducting fire prevention campaigns. SO (326).

69. Forest fire prevention needs a resurgence at the grass roots level through more localized application of known prevention techniques. Prevention programs could be strengthened by emphasizing person-to-person contact and using existing organization structures at the local level to a much greater degree. SO (330).

70. Bulldozing, fire, and herbicide treatments were used to clear brush fields near Mt. Shasta, California, prior to planting ponderosa pine. Sprayed plots with less than 5,000 cubic feet of brush crown volume, 5 years after pines were planted, are expected to remain fairly open and present minimum fire hazard and brush competition for 25 years. A dense brush cover with loss of most pines appeared certain on unsprayed plots. PSW (321, 322, 323).

71. Fuel breaks, one approach to California's wildfire problems, should be designed as part of the preattack and presuppression inventories and the fire control planning objectives. Guidelines have been developed to aid in developing fuel breaks in the Sierra Nevada mixed conifer type. PSW (333).

72. The most effective method of breaking seed dormancy in creeping sage, a shrub that dampens fire spread in flashy annual fuels, is a soaking in gibberellic acid at 500 parts per million for 4 hours with constant agitation. A study of methods to break dormancy and improve germination was conducted because direct seedings have been failures. PSW (334).

73. Certain saltbush species can be established by direct seeding and may reduce fire hazards on fuel breaks in California chaparral. Fourwing saltbush produces the best stands and largest plants of the species tested. PSW (335).

74. Over 2 million acres of forest land are treated annually with low-intensity prescription fires in the 13 southern States. Field and laboratory studies are underway at the Southern Forest Fire Laboratory to better determine the effects of forest fuel burning on air quality. SE (327, 328, 329, 337, 340, 344).

75. Good, but very temporary, control of oak-mountain mahogany chaparral is possible with carefully prescribed fire following treatment of the vegetation with herbicides. This technique appears less damaging to the site than wildfires or less carefully controlled broadcast fires. RM (336).

76. The results of two experimental treatments, burning with weekly clipping and no burning with weekly clipping, disclosed that fire accelerated time of death, but continuous, severe defoliation was the actual cause of 93 percent mortality for little bluestem. NC (339).

77. Results of a survey of operational prescribed burns in the Lake States during 1970 are summarized. NC (343).

2. FIRE MANAGEMENT METHODS AND SYSTEMS

78. Two major national projects, Project Aero-Fire and Project Sky-fire, are aimed specifically at applying new technology to fire management problems. Both of these projects will capitalize on developments pioneered in forestry research that now have the potential of fully utilizing advanced technology stemming from the space age. Never before have there been greater opportunities for this approach to fire management problems. WO (347).

79. The National Fire-Danger Rating System produces three indexes--Occurrence, Burning, and Fire Load--that measure relative fire potentials; fuel moisture, wind, and risk are the principal variables accounting for day-to-day fluctuations in fire danger. Three innovations in fire-danger rating are introduced in the new system: 1) it is solidly based on the physics of fire behavior, 2) it makes use of fuel models which account for local variations, and 3) improvements can be incorporated with a minimum of impact. RM (349, 350).

80. The 100-hour timelag fuel moisture component of the National Fire-Danger Rating System is computed from the daily moisture exchange factor and precipitation duration. The computational method is presented in tabular form for easy field use. RM (351).

81. The fine fuel moisture component of the National Fire-Danger Rating System will be adjusted according to the state of herbaceous vegetation. The adjustment is accomplished through solutions of rate-of-fire spread equations for various proportions of living herbaceous vegetation. RM (352).

82. A relationship between time-of-day and spread index for four interior Alaska stations is used to predict diurnal fluctuations in fire danger for planning fire control operations. PNW (357).

83. Of the 85,000 wildfires in Georgia from 1959 to 1968, 10 percent burned more than 10 acres each and accounted for 62 percent of the total acreage burned. Data on severity of weather, risk, and control action indicate shifting fire patterns within the State. SE (359).

84. Fire retardant delivery systems and research and development programs are traced from 1946 to the present. During 1970 the Forest Service used both helicopters and fixed-wing aircraft to deliver more than 13 million gallons of retardants to hundreds of fires. The major goal of retardant efforts is to control potentially dangerous fires at small size and to reduce the occurrence of costly and damaging conflagrations. WO (348).

85. Three different procedures are described for determining the salt content of present fire retardants: 1) for unthickened or thin, gum-thickened retardants, 2) thick, gum-thickened retardants, and 3) clay-thickened retardants. Since the effectiveness of long-term fire retardants is related to the concentration of the active fire-inhibiting salt, quality control is dependent on constantly monitoring salt content. INT (353).

86. A review is presented of currently used retardants, product evaluation procedures, application methods and types of aircraft used, conditions under which retardants are applied, mixing and pumping systems, and retardant research activities. This popular article reaches a new audience of liquid fertilizer manufacturers and applicators in hopes of generating new ideas in products and application methods. INT (354).

87. Brochure-form publication informs prospective retardant product suppliers and other interested persons of (a) the general nature of retardant research and development work conducted by the Forest Service, and (b) the procedures established in evaluating a proposed fire retardant product before it can be accepted for purchase and used on forest fires by Federal agencies. INT (346).

88. The effects of two fire retardants, diammonium phosphate and ammonium sulfate, on particulate emission and fire intensity were determined in this laboratory study. Particulate emission rate and total quantity of particulates were increased by diammonium phosphate treatment; ammonium sulfate fuel cribs had emissions similar to untreated cribs. Fire intensity was substantially reduced by both treatments. Future research on the retarding mechanisms of ammonium sulfate and diammonium phosphate could lead to the development of chemicals that catalyze glowing combustion with little flaming or effluent. INT (358).

89. A survey in the western United States determined how and why fire retardants are being used and obtained suggestions for better utilization of retardants. INT (355).

90. A computer simulation model of the fire control process is expected to provide improved efficiency in forest firefighting and fire prevention. PSW (360).

91. Wilderness fire management directions are being established for the 66,000-acre White Cap drainage in the Selway-Bitterroot Wilderness based on studies of fire history, fuels and fire potential, and plant communities. The wilderness fire study is providing inventory and planning tools needed by managers to provide for a more natural incidence of fire within the Wilderness Preservation System. INT (345).

3. FOREST FIRE SCIENCE

92. Fire in the northern environment was the topic of a symposium held in Fairbanks, Alaska, that explored aspects of wildlife in the subartic: its relationship to the natural environment, to man's use of that environment, and to fire control actions. PNW (361, 384).

93. Interior Alaska forest and range wildfire statistics for the period 1966-1969 are compared with the decade, 1956-1965, and the 30-year period, 1940-1969. PNW (362).

94. A Society of American Foresters' task force reviewed the role and use of fire in natural resource management as an aid to professional foresters in communicating an objective concept of fire in the forest. This task force urged all resource management agencies to commit significant research and management efforts toward understanding problems of smoke and other environmental effects of burning and alternatives to burning and to seek better understanding of fire's role in forest and range ecosystems. INT (382).

95. The natural forces operating in Montana forests which predispose them to wildfires are described, the present state of scientific knowledge of the production and dispersion of smoke from forest fires is presented, and alternative treatments of both fire and smoke in forests are discussed. INT (364).

96. Fire has always been part of the forest environment and is a natural agent for thinning, pruning, and fuel reduction. Fuel management planning and hazard reduction programs are suggested as approaches to the buildup of flammable fuels on much of the forest and range lands in the United States. PSW (385).

97. Equilibrium moisture contents are presented for common fine fuels in southeastern forests and Tobosa grass in the Southwest. SE, PSW (365, 366).

98. A theoretical analysis has been made of climatological influences on moisture characteristics of dead fuels. Three universal characteristics of dead fuels have been identified by numerical simulation: 1) reponse

of the fuel to climatological moisture-induced stress, 2) response of the outer layers of the fuel to both standard drying conditions and climatological stress, and 3) time required for a fuel to become independent of its previous moisture history. The first two characteristics provide a basis for fuels classification and the third permits evaluation of fuel moisture contributions to fire persistence and conditioning time for fuel moisture sensors. RM (372).

99. Moisture, ether extractive, and energy contents were measured for 1- and 2-year-old needles of ponderosa pine and Douglas-fir during two fire seasons in western Montana. Moisture content gradually increased during the summer. Ether extractive and energy contents were higher later in the summer. It is suggested that an interaction between moisture and extractives could contribute to crowning fires through a steam distillation mechanism. INT (381).

100. Field methods have been successfully used for inventorying fuel volumes and surface areas of logging slash and downed woody material. These estimates of physical properties are required for quantitative predictions of fire behavior. The technique is being used to inventory fuels for various fuel appraisal activities. INT (368).

101. Logging residue weights and volumes and a method of determining these are reported as well as the quantities of wood fiber which might be utilized. PNW (371).

102. For continuous thermobalance measurements on a cellulose sample kept at 226° C. for 1000 hours, a relatively simple pyrolysis model agrees with the experimental data within 1 percent over the entire range; but this agreement is significantly outside the experimental error in the measurements. Classical isothermal pyrolysis experiments provide data which adequately describe cellulose pyrolysis behavior under restricted experimental conditions, but do not permit extrapolation to other, quite different, conditions. The ultimate development of a completely consistent model should resolve the many apparently conflicting results observed through the years and permit meaningful extrapolations to more severe conditions. PSW (367).

103. Three major components of western cottonwood, cellulose, xylan, and lignin, have quite dissimilar thermograms, but all three are reflected in the thermogram of the whole wood. This independent behavior makes it quite likely that each component can be studied independently and the results used to predict its behavior in whole wood. This would greatly simplify study of the complex pyrolysis process. INT (379).

104. Cottonwood and cottonwood cellulose were treated with plant ash produced by ignition and this treatment caused changes in thermal behavior and pyrolysis products. However, the effect was not as pronounced as that resulting from naturally contained levels of minerals. This may mean that isolation of minerals by ignition produces changes which render the treatment less effective. INT (380).

105. Field burning tests in slash fuels in western Montana produced reasonably close agreement between observed rates-of-spread and predicted values. Mathematical predictions were consistently high and can probably be attributed to fuel discontinuities and the moisture content of extinction. INT (369).

106. Factors leading to the genesis of fire whirlwinds are examined under conditions of flat terrain, moderate burning conditions, and a known atmospheric temperature profile. During late summer periods, fire control forces might expect to find meteorological conditions permitting whirlwinds on less than 10 percent of the days. NC (373).

107. A tornado, causing damage to forest land along a 4-mile track, was photographed at a number of points near Elbow Lake, Minnesota. The pictures show an unusual combination of features that lend visual evidence to theoretical tornado models and such related vortex types as fire whirlwinds. NC (375).

108. A weighing system utilizing a large insulated platform supported on load cells has been designed to monitor and record the mass loss of large quantities of fuel over time. This development makes it possible to accurately record data on the mass loss rates of fuels in large free-burning fires that previously have been almost completely lacking. PSW (376).

109. Water-cooling at the rate of one gallon per hour effectively maintains temperatures of anemometers with sensitive electronic components below critical temperatures. PSW (378).

110. A new litter sampling device has been designed, fabricated, and tested. The impact sampler eliminates many of the past problems associated with determining the weight of forest litter samples. SE (383).

B. Improving Insect and Disease Control

1. LIFE HISTORY AND ECOLOGY OF INSECTS

a. Bark beetles

111. Flight activity of the mountain pine beetle is strongly influenced by air temperatures. Laboratory tests showed that flight started when air temperature was 65°F. and that sustained flight occurred at temperatures of 67° - 107°F. However, the warming influence of sunlight apparently facilitates flight at significantly lower air temperatures characteristic of higher elevations. RM (616).

112. Bark beetle population densities are commonly estimated from numbers of exit holes in the bark surface of host trees. Unfortunately, several adults may emerge through the same hole. A correction factor has been developed for estimating numbers of Ips pini beetles emerging from infested ponderosa pines. This will result in improved accuracy in studying and surveying populations of this tree better. PNW (627).

113. The influence of phloem thickness and the relationship of length of egg gallery to brood production of the mountain pine beetle were investigated in the laboratory. Over the range of phloem thicknesses examined, numbers of emerging adults increased linearly with increasing phloem thickness. In slabs where phloem thickness was not a limiting factor, numbers of emerging adults increased exponentially with an increase in inches of egg gallery. Thus, both phloem thickness and length of egg gallery significantly affect the production of beetles and the potential for subsequent attack. INT (573).

114. Three new species of mites inhabiting the galleries of bark beetles in North American conifers have been described and their biologies discussed. Illustrations and keys aid in identification of these associates of bark beetles. SO (584).

115. Ninety-six species of mites have been found associated with the southern pine beetle and allied scolytids beetles in an outbreak area in Allen Parish, Louisiana. Of these, four are known predators and an additional five species are suspected to attack the southern pine beetle. When abundant, these mites could be instrumental in limiting beetle populations. SO (620).

116. The inner bark lining the margins of lightning wounds is a fertile habitat for growth of microorganisms. A number of bacteria and yeasts are frequently encountered during the first 3 weeks following injury. To date, none of these microorganisms have produced substances that attract southern pine beetles. This finding supports the hypothesis that the first beetles attack lightning-struck pines at random rather than in response to microorganisms infecting the injured trees. SO (603).

117. Patterns of emergence of the mountain pine beetle attacking ponderosa pine in the Black Hills have been determined. The numbers and rates of emergence varied with aspect and height on the tree trunk. This information properly quantified, will permit more adequate evaluations of populations and related control decisions PNW (630).

118. A nematode, Omemeea maxbassiensis, was found inhabiting galleries of the bark beetle, Leperisinus californicus, in green ash. This new bark-beetle associate has been described and illustrated. It may be an important factor in limiting populations of this insect. RM (613).

119. The characteristics of diseased elm trees and the patterns of attack by the elm bark beetle, Scolytus multistriatus, have been analyzed in Yugoslavia in a study financed under PL 480. The severity of attack varied

significantly between trees and stands. In all-aged, mixed stands, mortality ranged from 0 to 47 percent, this suggested that a diversity of factors influenced the course of the disease. By felling trees with a certain beetle attack density, setting up trap logs, and treating cut material with chemicals, populations of elm bark beetle were reduced thereby avoiding a potential epidemic. WO (612).

b. Defoliators

120. Similarities in the seasonal growth pattern of ponderosa pine and incense cedar enabled entomologists to determine impacts of the pine needle sheathminer. This defoliator feeds extensively on ponderosa pine. Since cedar is immune to attack, the growth reduction in ponderosa pine due to insect injury can be accurately estimated by comparing growth in the respectve species during outbreaks. RM (638).

121. Nearly mature larvae of the jack-pine budworm commonly drop from their host tree when disturbed. Many of the dislodged larvae are killed by predators. Studies show that mass drops may result in reduction of larval and pupal population densities up to 75 percent. NC (606).

122. Normally the western hemlock sawfly feeds on foliage produced during the previous year (a situation that arises, but when sawflies increase in number they feed on current year's foilage). Sawflies fed on young foilage produced in the current year suffered a 65 percent reduction in survival of females, a 10 percent reduction in males, and a 26 percent reduction in egg laying of surviving females. This selective effect on females may account for this sawfly's apparent inability to reach outbreak proportions. PNW (602).

123. In a cooperative study by FAO sponsored in Colombia, a looper, Glena bisulca, was found to be the cause of serious defoliation and death of planted cypress. Tree mortality occurred primarily on flats and in drainages. It was recommended that such areas should be planted with nonsusceptible tree species. SE (590).

c. Shoot- and tip-feeding insects

124. Development of the European pine shoot moth in a Michigan planting of red pine occurred progressively later in each of 5 successive years. This trend was believed to be due to habitat cooling as the trees grew larger. Insect development was more advanced on adjacent smaller trees. These findings are further evidence of the effects of tree size and crown density on microclimate and related variation in rates of insect development. NC (617).

d. Sucking insects

125. Control of alternate host plants leads to control of the Saratoga spittlebug, a serious pest of red pine. Reduction of sweet-fern to the point

where it covers less than 25 percent of the ground keeps spittlebug populations at subeconomic levels. NC (607).

126. The potential damage of the Saratoga spittlebug to red pine can be predicted by estimating the percentage of ground occupied by sweetfern and that occupied by other plants that serve as alternate hosts. A simple graph has been developed for the land manager to use in rating the potential damage by this insect. NC (649).

127. The tuliptree scale is a serious pest in Pennsylvania. An effective means of augmenting natural control of this pest has been developed. A 4-inch wide band of sticky material--not a poison--is placed around the tree trunk. It bars access of ants to the tree crown when they interfere with native parasites and predators. Exclusion of ants increase the effectiveness of natural enemies of the scale by as much as 50 percent in a single year. NE (588).

128. A device for collecting the honeydew excreted by scale insects has been developed and successfully used under a wide variety of field conditions. The device and method are being used to estimate scale insect densities and the probable damage to trees, shrubs, and annual plants. NE (580).

e. Seed and cone insects

129. Annual cone crops and associated insect damage vary widely in seed-production areas of red pine. Cone crops fluctuate almost unpredictably from year to year. Sixty-six percent of the variation in cone damage is associated with variation in cone abundance. This information, coupled with the fact that insects attacking cones of red pine are almost entirely dependent on red pine cones for both food and reproduction, means crop size is a primary determinant of the rate of change in numbers of cone insects. NC (615).

130. Control of the pecan weevil depends upon distinguishing and quantifying insect-infested seeds. In the past, identification of weevil-inhabited nuts was almost impossible because surface damage indicating that a weevil was present was indistinguishable from other kinds of damage. The identifying characteristics of weeviled nuts have been described and illustrated, so that it is possible to identify them in time to decide on the need for control. NE (589).

131. In a North Florida seed orchard nonlethal damage to female conelets of slash pine by a thrips, Gnophothrips fuscus, resulted in mature cones having areas of sunken, deformed cone scales. Damaged cones were significantly shorter and they yielded fewer total seed and fewer filled seed per cone. This is the first report of such damage by thrips to female slash pine strobili. SE (586).

132. A number of economic and biological factors must be considered in evaluating losses caused by insects in slash pine seed orchards.

Included are: tree and seed values, expected yields, expected losses of seed due to insects without a control program, and the effectiveness of control method. Knowledge of clonal productivity and susceptibility to insect attack also provides for more efficient and effective control of insects that damage cones and seeds. SE (585).

133. Collections of mature cones disclosed the occurrence of seedworms in three pine species growing in the Mid-South. Two species of Laspeyresia were found: one, L. ingens, was essentially limited to loblolly pine; the other, L. toreuta, occurred in all three pines but was much more prevalent in loblolly pine. Cones of Virginia and shortleaf pine were infested to a lesser degree. SE (591).

134. The Nantucket pine tip moth was found to be a major enemy of young, first-year conelets of shortleaf pine. Symptoms of attack have been illustrated and discussed. In 1968 and again in 1969, 22 percent and 31 percent of the first-year conelets of shortleaf pine were lost because of feeding by the Nantucket pine tip moth. The tip moth caused only minor mortality of conelets of loblolly pine. Late-season attacks by the tip moth on overwintering shoots and buds did not preclude development of female flowers the following spring. Guidelines have been prepared for the proper timing of chemical control in seed orchards. SE (652, 654).

135. A bibliography has been published that contains literature and processed reports through 1970 on insects known to be associated with the destruction of cones and seeds of North American conifers. The 719 citations are cross-referenced by tree and insect species. This compendium will guide managers of seed orchards and researchers to literature pertinent to their problems. SE (574).

f. Wood-products and boring insects

136. That the eastern subterranean termite selectively eats the softer or less dense early wood of coniferous woods is a familiar observation. Studies using diffuse-porous hardwoods showed that feeding by termites decreased as wood hardness increased. A similar relationship was found between loss in weight due to feeding by termites and specific gravity of the wood. Therefore, hardness and specific gravity must be taken into account when the resistance to termites of chemical extractives from woods are being studied. NC (577).

137. Species of termites differ widely in their response to humidity. Knowledge of their behavior under various humidities is of great importance in culturing each species in the laboratory. It also helps explain marked differences in survival of worker and soldier termites. WO (632).

138. Stain and decay are now shown to be associated with galleries of the carpenterworm in three species of southern hardwoods. SO (634).

139. Damage by insects leads to a rejection of from 3 to 13 percent of the stave blanks for bourbon barrels produced by mills in Ohio. This is a conservative loss estimate, since the mill operator also rejects infested trees, logs, and stave bolts before processing. An illustrated guide has been developed to aid the mill operator and stave buyer in identifying the types of insect injury leading to these losses. NE (579).

140. The Columbian timber beetle causes a serious degrade of hardwood lumber. Studies in Georgia have shown that three generations of this insect develop each year and that adults overwinter on the host tree. This information will be useful in developing both chemical and cultural controls for this insect. SE (622).

141. The flag-worm defect caused by the Columbian timber beetle is generally considered a serious defect to hardwood lumber. Values and uses are substantially reduced. However, the potential market value of this insect-caused defect as a decorative wood product has been studied. If a strong market for wormy paneling, furniture, and specialties could be developed, it would provide a lucrative outlet to landowners who own millions of otherwise low-quality trees. SE (621).

142. A borer, Saperda inornata, attacks the small stems and branches of trembling aspen in Michigan. The complete biology of this beetle and its impact on the host have been worked out. The complete biology of another hardwood borer, Oberea schaumii, in trembling aspen in Michigan and Wisconsin has also been determined. This information will be useful in developing and evaluating controls for these insects. SE (623, 624).

143. The locust borer is a serious problem, particularly where black locust has been extensively planted for land reclamation. First-year attacks by this borer were found to be randomly distributed. Attacks tended to be more concentrated during the second year. In the third year, attacks were found to be aggregated in one area and randomly distributed in another portion of the general infestation. This attack pattern affects control treatments and the possibility of overlooking some infested trees when treating an area. NE (650).

g. Root and root-collar feeders

144. Six genera of white grubs occur in pine plantations in Wisconsin and Michigan, but only those of the genus Phyllophaga are important destroyers of seedlings. Control of white grub was recommended in the past when counts reached 0.5 grub per cubic foot of soil. The finding that grubs at this frequency cause up to 40 percent mortality of seedlings by the second growing season after planting leads to the conclusion that control should be started at lower population levels. NE (594).

145. The pales weevil, pitch-eating weevil, and Pissodes spp. are all important pests of seedling and young sapling pines in the South. Recent studies in North Carolina and Florida have helped to explain the

circumstances under which these weevils attack pine reproduction in the Southern Appalachians and in the Deep South. Species in the population of weevils differed markedly in each general area. These findings should lead to more effective management to minimize impacts of these tree killers. SE (636).

146. The pales weevil is very destructive to young pines planted on recently cutover forest land. Chemical controls, while effective, may soon be withdrawn from general use. Several alternative methods are proposed to control this threat to regeneration. SE (641).

147. Damage by the pine root-collar weevil is least in red pine plantations in cooler areas of northern Michigan, and damage decreases with distance of the host from the nearest infestation. Three hazard zones based on areal patterns of temperature have been suggested. It is recommended that planting in the high-hazard zone should be at least one mile from an infestation. In the medium zone planting should be at least one-half mile away to insure minimal damage. The only restriction for the coolest zone of low hazard was to refrain from planting red pine near a stand of Scotch pine because of its susceptibility. NC (608).

h. Mathematical models

148. Mensurational studies of forest growth and yield including losses due to insects often employ a mathematical model or a set of equations to describe changes in stand parameters over time. In the past, the individual equations in the model have been fitted one at a time by the method of least squares, but this method of estimation is not entirely satisfactory. A method of handling a forest growth and yield model as a system of equations has been developed, in which all coefficients in the model are estimated simultaneously. The technique involved is well known and widely used in econometrics, but it had never been applied before to the analysis of forest stand dynamics and insect impacts. NE (600).

149. Researchers studying populations of insects and their impacts must commonly develop an appropriate linear regression model from a large amount of data. The regressions to be calculated for even a few independent variables can become too numerous to handle conveniently by conventional methods. A new computer program enables the researcher to screen all possible combinations of his independent variables with relative ease. The program calculates coefficients of determination for all possible combinations of up to 20 independent variables. NE (595).

i. Miscellaneous

150. Adults of a fly, Pholeomyia comans, have been found to enter the nests of the destructive town ant. Biological studies show that the adult lays eggs in the underground cavities where the developing maggots feed on decaying plant material and refuse deposited by worker town ants. This fly does not affect the town ant population. SO (619).

151. Insects damage the trees and shrubs planted throughout the Great Plains to protect crops, soil, and livestock; to provide for wildlife habitats; and to provide noise abatement, beautification, and privacy. These introduced plants support tree pests which could not otherwise exist in the region. An illustrated key to 226 species of insects will aid in identification of potential insect pests and damage by them. RM (637).

152. Insects that damage five genera of important browse plants have been identified. This information will permit range scientists to measure and assess the impact of these insects on the range resources and provide a useful reference for future surveys. INT (627).

153. A survey of the forest insects attacking Caribbean pine in northeastern Nicaragua was sponsored by FAO in the spring of 1971. The Nantucket pine tip moth and two engraver beetles, Ips calligraphus and I. cribricollis, were the most important species found in this area. Other damaging insects were identified, and future actions were recommended. SE (651).

2. INSECT PHYSIOLOGY, NUTRITION, AND REARING

154. A rearing technique that approximates field conditions was developed for the pales weevil. Bolts of loblolly pine were buried in screened beds of soil in the greenhouse; others were buried with ends exposed in cages in the field. Adult weevils were introduced into the enclosures. Associated organisms, weights, sex ratios, and behavior of weevils showed the weevils reared in the greenhouse are comparable to those collected in the field. SE (669).

155. The lipids found in phloem of loblolly pine, particularly the neutral lipids, were fractionated and bioassayed to determine whether they would stimulate feeding by the pales weevil. The natural stimulus provided by fresh phloem evidently was reduced by the fractionation treatment. However, significant feeding occurred in response to the fraction whose principal constituent was Beta-3-sitosterol. Results also indicated that substances associated with the sterols may play a role in inducing feeding. SE (682).

156. The effect of adding an emulsifier to an artificial diet was evaluated for larvae of the pales weevil. Hypothetically, the improved dispersal of fat-soluble ingredients in an emulsified aqueous medium should lead to improved growth of larvae. Results suggested that the emulsifier did improve the diet. SE (681).

157. Attractants are responsible in part for the aggregating behavior of the smaller European elm bark beetle under natural conditions. Virgin female beetles when tunneling in the bark produce a strong attractant. More beetles of both sexes attack infested bolts of elm in response to this attractant than to any other experimental treatment. Since a few beetles are also attracted to bolts of elm either uninfested or infested with male

beetles, odors from the elm are also involved. Thus, both insect-and host-produced chemicals may have to be used to trap the beetle for control purposes. NE (672).

158. Rearing individual larvae of the smaller European elm bark beetle in the laboratory is difficult and costly; yet considerable numbers are needed for studies of parasites and other experimental purposes. Improved techniques have permitted continuous rearing of 10 generations of bark beetles on two different media. A special medium was needed for oviposition and rearing of young larvae. No apparent change in behavior or physiology of the beetles was noted after the 10 generations of continuous rearing. NE (667).

159. Techniques have been developed to force overwintering larvae of the European pine shoot moth to emerge from infested shoots and to prevent contamination of rearing dishes by molds. Forced emergence avoids the need to dissect shoots and enhances survival of insects. Use of these techniques enables entomologists to rear large numbers of insects needed for identification of the sex attractant or for production of parasites. PNW (661).

160. Male European pine shoot moths were used to develop a reliable bioassay for attractants extracted from adult females. The incidence and type of male sexual responses depended upon the quantity of extract and the length of time males were preconditioned with high illumination. A quantity of pheromone equivalent to only 0.005 to 0.01 females induced a response by the males. Repeated exposure to the pheromone rapidly decreased the response. PNW (664).

161. A histological study was conducted to determine the effects of tepa, a sterilizing chemical, on male pupae of the eastern spruce budworm. An increase in protein concentration occurred in the fat body and testes of male insects treated with tepa. Tepa evidently affected the cells' ability to regulate levels of hormones or metabolism of proteins, or both. Critical changes in mature sperm also occurred. NC (655).

162. Jack-pine budworm larvae, treated with radioactive phosphorus-32 as a tracer, were released on the ground at various distances from a plantation of jack pine. Recapture 24 hours later showed how recovery decreased with increasing distance from the host trees. This information will be useful in understanding and predicting dispersal of larval populations. NC (658).

163. Larvae of the elm spanworm fed on hickory foilage developed faster than on oak. The adults were also larger and laid more eggs than those developing on oak. Concentration of soluble carbohydrates, free amino acids, and 11 major inorganic constituents differed in juvenile and mature leaves of pignut higkory and southern red oak. Undoubtedly, these differences contribute directly and indirectly to the behavior and development of this defoliator. SE (663).

164. Yellow and blue chromoproteins color the fluids in the body of larvae of the western spruce budworm. These pigments contributed to the primary coloration of budworms. Differences in concentration of the pigments may indicate qualitative differences between budworm populations and may be useful as a marker trait. PNW (676).

165. Lipids in southern lyctus beetles increase quantitatively during larval development and are utilized during the transformations from larva to pupa to adult. Larvae lacking these lipids fail to develop. SO (670).

166. Injection of a juvenile hormone analog into the western spruce budworm inhibits the shortening of certain internerve connectives during the metamorphosis of the nerve cord. This inhibition is related to the stage of development of the insect at the time of injection. PSW (677).

167. Neuromuscular studies on the wax moth have shown that bromolysergic acid diethylamide (BOL-148) when injected into larvae, produces a reversible paralysis of the body wall. Nerve and muscle electrical activity remains unaffected during paralysis. It is concluded that the drug blocks neuromuscular transmission in this insect. SE (656).

168. Insect electro-antennograma (EAG's) are becoming increasingly useful in research on sex and host attractants. Pitfalls in the use of this technique and in the interpretation of EAG data must be recognized and avoided. SE (657).

169. Males of the cone moth, Dioryctria abietella, respond to a crude extract from the abdomens of females. Flight responses of males to this sex attractant, mating behavior, and mating periods have been worked out under laboratory conditions. This information will have application in the management of the cone moth in southern pine seed orchards. SE (665).

170. Adult town ants leave a trail of pheromone which is followed by foraging ants in the colony. The major volatile component of the trial-marking substance has been identified as methyl 4-methylpyrrole-2-carboxylate. When synthesized, this chemical may be useful for trapping this pest. SO (683).

171. Both sexes of the western pine beetle are attracted by a pheromone produced by female beetles. This response is enhanced by myrcene a terpene constituent of the host tree, ponderosa pine. Myrcene itself is not attractive. This synergism produced by the combined chemicals contributes to the attraction of masses of beetles to host trees. PSW (660).

172. The fine structure of the fungal tube (mycangium) and the associated gland cells of the southern pine beetle have been described. Chemicals secreted by the gland cells are essential to the symbiotic relationship between fungi maintained in the tub and the beetle. Similar structures and fungal associations occur in other destructive bark beetles such as the western pine beetle. SO (668).

173. Male engraver beetles, Ips grandicollis, initiate attacks on weakened loblolly pines in response to olfactory stimuli. Volatile terpenes emanating from the host phloem cause this attraction. Host attractiveness is dependent on the qualitative and quantitative composition of terpenes which, in turn, are related to the physiological condition of the host. SE (684).

3. BIOLOGICAL CONTROL OF INSECTS

a. Invertebrate parasites and predators

174. The mite Pyemotes parviscolyti is carried on the bark beetle Pityophthorus bisulcatus. It attaches itself to all stages of the insect except the adult. It does not injure the bark beetle directly, but heavy infestations may prevent mating and/or flight of the beetle. SO (698).

175. Dendrosoter protuberans, recently introduced from France, may have great potential as a parasite of the elm bark beetle. Mass rearing and biological studies underway in the United States will determine the effectiveness of this species alone and in combination with native parasites. NE (690).

176. Bracon politiventris is an important parasite of the western spruce budworm in Colorado. Studies have been made of the life history, habits, and host-searching behavior of this natural enemy. Each female wasp attacked and paralyzed about 10 budworm larvae in their feeding sites and deposited about 100 eggs externally on the surface of each budworm. RM (695).

177. In Alaska, western hemlock looper pupae are attacked by eight species of ichneumonid parasites. Four species make up 97 percent of the parasites reared from host material. Apechthis velox occidentalis is the most common parasite. Means for identifying these parasites and notes on their biology are summarized in this paper. PNW (704).

178. A key to the diagnostic features of the subfamilies of Ichneumonidae has been prepared. This will help entomologists in determining the subfamily in which adult ichneumonid parasites of forest insects belong. PNW (705).

179. Length of life, egg-laying capacity at different age intervals, and effect of light intensity on host-finding behavior of the parasites Apechthis ontario and Itoplectis quadricingulatus have been determined. Numbers of hosts killed and parasite progeny produced were criteria used to compare single-species and mixed-species performance. Results indicate it is best to introduce all the pest's primary parasites rather than to restrict importation to a preselected single species. PNW (701).

180. A survey in the Piedmont of North Carolina indicated that parasites and predators of the southern pine beetle destroyed 24 percent of the brood. Woodpeckers and the insects Thanasimus dubius and Scolopcelis mississippensis were the most effective predators, while Roptrocerus xylophagorum and Coeloides pissodes were the principal parasites. SE (697).

181. Larvae of the fly parasite, Medetera aldrichii, enter galleries of the mountain pine beetle through beetle entrance holes. The fly larvae complete their development near beetle-created openings that lead from the galleries to the exterior. These larvae are thought to cause a major share of the beetle mortality that occurs between August and the following May. RM (702).

182. Between 1961 and 1965, 15 species of predators from India and Pakistan were released in North Carolina to determine their effectiveness in controlling the balsam woolly aphid. Recoveries to date have not demonstrated that any of the predators have become established. Lack of establishment is attributed largely to differences in climate between the old and new environment and to poor prey acceptance on the part of predator larvae and ovipositing adults. SE (685).

183. The development of mass-rearing techniques is a vital part of biological control programs. Studies at the Corvallis, Oregon, laboratory reveal that host pupae placed in plexiglass templates are readily accepted by parasites. This technique will find application in mass-producing parasites for release in forest insect outbreak areas. PNW (700).

b. Vertebrate predators

184. Predation by woodpeckers is an important natural control for trunk borers in southern hardwoods. Recent studies show significant predation of fourteen species of trunk-boring insects in Mississippi. Predation is greatest during January and February in trees less than 6 inches in diameter. SO (703).

c. Insect pathogens

185. The balsam woolly aphid is affected by a fungus disease caused by Fusarium nivale. Preliminary observations have been made on the occurrence and symptomology of this disease in North Carolina. SE (688).

186. The microflora of healthy adult and larval stages of the southern pine beetle included the bacteria Aerobacter aerogenes, Alcaligenes faecalis, and Serratia marcescens and the fungi Aspergillus sp. and Penicillium sp. Seven of the organisms recovered have been found in diseased beetles in other studies. SE (696).

187. Specific techniques, production figures, and costs have been determined for mass propagating the viruses of the European pine sawfly and the gypsy moth. Protocols for safety tests must be accepted by EPA before adequate safety data can be obtained to support registration of the virus for operational use. NE (691).

188. Strains of different serotypes of Bacillus thuringiensis may be equally effective against the gypsy moth. This suggest that efforts to find new potent strains of Bt should not be limited to a specific serotype. NE (687).

189. Diseases have a significant effect in altering gypsy moth population numbers. The disease complex varies widely between population types. Noninfectious diseases may play an important regulatory role in natural populations. NE (699).

190. Sparse populations of gypsy moth are more significantly affected by parasites than are dense populations. In dense populations, viral infection represents the primary mortality factor, while it is virtually nonexistent in sparse populations. The isolation of pathogens that can be used as biological control agents, and the development of techniques for forecasting disease incidence in gypsy moth populations are the ultimate goals of this research. NE (686).

191. Blood cells of the gypsy moth can be maintained in live culture apart from the insect. These cells support live virus when infected blood is added to the culture. Production of gypsy moth virus by this procedure would eliminate the present requirement of maintaining large colonies of insects for virus production. NE (693).

192. Elimination of insect debris and undesirable microorganisms in crude virus suspensions is required for safety tests and field evaluations of efficacy. A procedure has been developed for cleaning large volumes of virus material for these purposes. NE (694).

193. Two distinctly different nuclear-polyhedrosis viruses occur in the Douglas-fir tussock moth. Knowledge of the occurrence and development of these viruses in populations of the host insect is needed for evaluation of their effectiveness as microbial control agents. PNW (689).

4. CHEMICAL CONTROL OF INSECTS

a. Insecticides

194. Seventeen analogs of dimethoate were prepared and tested against mice and houseflies. While most of the compounds investigated were highly toxic to mice, only compounds which were N-mono-substituted showed insecticidal activity. SE (712).

195. Significant differences in the ecosystems and in crop and/or resource values involved have resulted in different insecticide use patterns employed against forest and agricultural pests. This has had a tangible effect on contamination problems in the respective environments. Various characteristics and amounts of different insecticides may be utilized in an integrated control approach. The potential for using Zectran in managing spruce budworm populations is discussed as an example. NE (731).

196. Laser holography has been used to study the characteristics and behavior of insecticide aerosols. It allowed direct three-dimensional stop-action study of spray particles as they landed on western spruce budworm larvae and their silk webbing. The hairs of this insect effectively intercepted small spray droplets. PSW (725).

197. Drift from herbicides and insecticides poses a potential hazard to sensitive nontarget organisms and increases residue problems in plants, animals, air, and water. The potential drift hazard is greater from aerial application of herbicides than from insecticides because of the chemical nature of herbicides and their patterns of use. The quantity and extent of drift can be reduced by regulating spray formulation, rate of application, atomization, and method of application and by giving proper consideration to the role of weather in affecting spray behavior. PNW (720, 721).

198. The effectiveness and safety of aerial applications of pesticides depend on obtaining maximum target coverage with minimum concentrations and spray volumes, and by reduction of drift into nontarget areas. Improved aerial application technology will lead to more efficient target coverage and, in turn, a more favorable cost-benefit ratio for pest control programs. PNW (722).

199. Large numbers of orange tortrix, Argyrotaenia citrana, larvae reared on an artificial wheat-embryo diet were topically treated with four insecticides. The test compounds, in descending order of toxicity, were pyrethrins, Zectran, DDT, and malathion. PSW (727).

200. A water-soluble salt of Zectran was applied topically to the dorsal surface of individual body segments of the western spruce budworm. Mortality was greatest when application was made to the head or seventh abdominal segment. PSW (728).

201. Zectran was tested as an aerosol against the larvae of the California oakworm, Phryganidia californica, the adult of a primary parasite of the oakworm, Itoplectis behrensii, and the adult of a hyperparasite, Dibrachys cavus. The increasing order of susceptibility to the insecticide was oakworm, Itoplectis, and Dibrachys. To minimize this adverse effect on parasites, oakworms should be sprayed when they are in the 3rd and 4th larval stages. PSW (726).

202. Fourteen insecticides were evaluated for contact toxicity to larvae of the pine butterfly in a laboratory spray chamber. All candidate materials except trichlorfon were more toxic than DDT. Several insecticides might provide adequate control of this defoliator at application rates of less than 1 pound per acre. However, field tests are still needed to establish the minimum effective dosages of the most promising compounds. PSW (717).

203. Ten insecticides were tested in aerosol form against adult needle miners of the genus Coleotechnites. Pyrethrins were about six to seven times more toxic than malathion, the insecticide currently registered for use in suppression of needle miner epidemics. The relatively higher toxicity of pyrethrins, together with the development of a stabilized formulation, make them promising candidates for practical control. PSW (718).

204. Forty insecticides and one antifeeding compound were tested against pandora moth larvae in a search for safer candidate chemicals for field trials. Twenty-one insecticides were more toxic than DDT. The pyrethrins formulation was 288 times more toxic than DDT. PSW (716).

205. Thirteen insecticides were tested against the California five-spined engraver and six were tested against the western pine beetle to find alternatives for lindane. Five compounds--Zectran, Dursban, malathion, dichlorvos, and pyrethrins--showed promise for further research and field testing. PSW (715).

206. Bioassays were conducted to determine the effects of storage procedures and dose on the degradation and effectiveness of dicrotophos in controlling the smaller European elm bark beetle. Results suggested that dose of dicrotophos was the most important factor affecting beetle feeding. NE (707).

207. Twigs were taken from American elm trees sprayed with methoxychlor by mistblower and helicopter to determine residue levels and treatment effectiveness against the smaller European elm bark beetle. Spray deposits were higher and more homogeneous for mistblower-treated trees than for helicopter-treated trees. The mistblower treatments, correspondingly, were more effective against the beetle. NE (706).

208. A spring application of 40 grams of phorate granules raked into the soil effectively protected individual young ponderosa pines from damage by western pine tip moth for two growing seasons. Dimethoate sprayed in the spring and summer provided immediate control of the tip moth during the first generation but not the second. These findings suggest that dimethoate should be applied at the time of larval emergence. More frequent treatments will be required than with phorate. RM (729).

209. Eight systemic insecticides were tested against the Saratoga spittlebug. Applications of granules of baygon, temik, furadan, and phorate provided 94 to 100 percent control. Baygon appeared to be the best and "safest" chemical. NC (732).

210. Disulfoton and Monitor[R] are absorbed and translocated from the roots of loblolly pine seedlings upward to the new terminal growth. Bioassays with pales weevils revealed that Monitor was more effective during the first 15 days, while disulfoton was more effective during the 30- to 90-day period. These compounds deserve detailed study to determine the mechanisms of absorption and translocation and possible use for weevil control. SE (730).

211. Insecticides added to concrete at the time of mixing have prevented tunneling by subterranean termites over or through cracks in the concrete under field conditions. Laboratory studies showed that the termites died when they were placed directly on dieldrin-treated concrete. SO (708).

212. Laboratory tests indicate that the Formosan subterranean termite and two species of native subterranean termites differ in their susceptibilities to aldrin, chlordane, dieldrin, and heptachlor in soil. The Formosan termite is able to tube through soil containing higher amounts of insecticide than the native termites. Also, the native species usually succumb more rapidly than the Formosan species when placed directly on treated soil. SO (709).

213. Analyses of residues and degradation products of technical heptachlor weathered 4 years in an Oregon soil revealed an unknown component in layers below the soil surface. Analyses showed the unknown to be 1-hydroxy-2, 3-epoxychlordene which had not been reported previously as a degradation product in heptachlor-treated soil. SO (710).

214. Numerous termiticides have been under study for many years in southern Mississippi. Of these, aldrin, chlordane, dieldrin, and heptachlor applied at several concentrations and rates still remain effective after 17 to 21 years. SO (714).

215. Dicrotophos was injected as a liquid into the trunks of mature slash pine trees to control several seed and cone insects. Direct injection into bored holes gave consistently better control. This method also had the advantages of permitting individual crop-tree treatment and a single insecticide application each year to control most of the known major seed-destroying insects affecting slash pine. SE (723).

216. Tests were conducted to determine if a flower thrips, Gnophothrips fuscus, and southern cone rust could be controlled with mistblower applications of the fungicide ferbam combined with either malathion or heptachlor. The feasibility of controlling southern cone rust with mistblower applications of ferbam was not established but thrips control was obtained. SE (711).

b. Natural products

217. Pyrethrins and pyrethroids have long been used as insecticides. However, their instability when exposed to air and light, as well as their

high costs, have prevented large-scale use in agriculture. The combination of an antioxidant and an ultraviolet screening agent in a mineral oil formulation stabilizes pyrethrins for at least 4 hours thus permitting their use in control of some forest insects. PSW (724).

218. Laboratory tests have been conducted on stabilized pyrethrins to provide data necessary for planning field trials against the western spruce budworm. Results indicated that only slight residual activity can be expected from the stabilized pyrethrins. Reliance for control must therefore be placed principally on direct contact by the spray droplets. PSW (719).

5. SILVICULTURAL AND MECHANICAL CONTROL OF INSECTS

219. Losses of lodgepole and whitebark pine due to the mountain pine beetle were compared in study areas within two mixed species stands at high elevations. Results suggested that the beetle tends to prefer the tree species in which it developed. Moreover, mortality of the insect in the host species was different than that in another tree species. This information has direct implications for silvicultural manipulation of stand composition to minimize losses. INT (733).

220. The California risk-rating system was tested on ponderosa pine in western Montana to determine the classes most frequently killed by Dendroctonus beetles. Almost four times more high-risk trees were killed than other trees in the stand. Recognition of these trees permits selective removal and a minimizing of beetle-caused tree mortality. Such selective cutting is especially important in maintaining areas where esthetic values are high. INT (734).

221. Severe tree killing by the mountain pine beetle is an increasing problem in older, second-growth ponderosa pine stands of Oregon and Washington. Excessive competition between trees favors the occurrence of beetle outbreaks. This indicates that thinning of dense stands of ponderosa pine has promise as a silvicultural method of preventing outbreaks of this insect. PNW (735).

6. HOST RESISTANCE TO INSECTS AND TREE PHYSIOLOGY

222. Scotch pines grown from seed collected at different locations in Europe and Asia were exposed to the pine root collar weevil in Michigan. Mortality due to the insect was least for varieties from western and southern Eurasia (Scotland, Spain, southern France, Italy, Yugoslavia, Greece, Turkey, Georgian USSR) having a moderate growth rate, and highest for rapidly growing varieties from central Europe. NE (741).

223. Small differences in relief on a flatwoods site were related to soil-water regime and diameter growth of 40-year-old loblolly pines. The soil-water parameter and tree growth responses indicate an unstable environment on flat sites that probably affects tree rooting and, in time, susceptibility to bark beetle attack. Results of this study partially explain the development of tree decline on flat sites, the very drastic loss in oleoresin exudation pressure in trees on such sites during drought periods, and consequent increased susceptibility to the southern pine beetle. SO (738).

224. Oleoresin exudation pressure (OEP) of loblolly pine was highly correlated with relative water content (RWC) of needles and the water potential (WP) of twigs measured by the pressure chamber technique. Oleoresin exudation flow was correlated with RWC and WP and not at all with OEP. The manometric technique of measuring OEP is a convenient and inexpensive way to estimate water stress in large loblolly pines. SO (737).

225. Periodic outbreaks of the fir engraver beetle have resulted in severe depletion of true fir stands in western North America. Endemic populations have caused continuous, less spectacular loss. Recent research has shown that populations of the insect in flight may be trapped or diverted to reduce such losses. PSW (736).

226. An accurate procedure has been developed for quickly approximating monoterpene composition in trees being studied for resistance to bark beetle attack. This procedure is about three times as fast as the standard technique. PSW (740).

7. SAMPLING AND SURVEY METHODS

227. Radiographic techniques have been perfected to detect and count the parasite Agathis pumila in host larvae of the larch casebearer. Large parasite larvae have been detected in host insects with 100 percent accuracy, but the smaller larvae cannot be detected consistently. INT (743).

228. The development of adequate sampling methods requires knowledge of the target insect's habitats and behavioral activities. The egg-laying habits and patterns of the fall cankerworm, and the number of eggs that constitute a mass have been determined and form the basis for an egg mass sampling method. NE (748).

229. A method has been developed for rapidly estimating the population levels of European pine sawfly egg clusters or larval colonies in young red and Scotch pine plantations. Populations are classified from the percentage of trees infested with sawflies. Sample data combined with a knowledge of the insect's damage potential provide the basis for judging whether or not suppression measures are needed. NC (753).

230. Crown closure measured on aerial photos can be used to delimit timber stands likely to succumb to bark beetle attack. A crown closure-crown diameter comparator has been used on aerial photos to relate the images to stand density conditions on the ground. The method directs the forest manager to those stands needing thinning first. PSW (749).

231. Many improvements have been made in airborne scanning instruments and in data preprocessing and processing techniques. Despite spectral and radiant differences measurable on the ground, the accuracy of airborne scanners is still not adequate. Indications are that a single-aperture system may provide more accurate results for insect surveys. PSW (750).

232. The spread and growth of bark beetle infestations are dynamic processes operating within a forest ecosystem. These changes can be characterized quantitatively by annually counting the number of dead trees on medium scale color aerial photographs followed up with some ground checking. An example is described in detail. PSW (746).

233. Automated methods of pattern recognition to identify land uses were used on microdensitometer readings of infrared film for each of three high-altitude aircraft missions and the Apollo 9 photographic mission. The results from Apollo 9 photography were as good as those from the high-altitude aircraft photography. PSW (747).

234. Multiseasonal infrared color photographs taken from high altitude and from space were scanned using an automatic recording microdensitometer. Film densities were related to ground conditions to develop signatures for thirteen forest and nonforest land-use classes. Further research is needed to isolate and make adjustments for undesirable variation. PSW (745).

235. Photointerpretation was tested for thirteen forest and nonforest land classes on high-altitude infrared color photographs. Comparisons made with the results of two independent studies indicate that microscale infrared color photography can be useful for forest area estimates and stratifying forest area in forest inventories. PSW (742).

236. Sensitometry is important in the automatic interpretation of aerial film. Several hypothetical examples are given to illustrate errors caused by using uncalibrated film microdensities in the analysis of infrared color films. PSW (744).

237. The RS-2 field sprectrometer is lightweight and self-contained. It is designed to obtain simultaneous data in four light bands which are identical to those of the Earth Resources Technology Satellite multispectral scanner. This instrument has been used to show the relationship between target radiance measured on the ground and the target radiance measured 10,000 feet above the ground. PSW (751).

8. FOREST PEST MANAGEMENT

238. The natural factors that control changes in gypsy moth numbers are varied and interact with one another in complex but somewhat predictable ways. In the past, single approaches (e.g., parasites, insecticides) have been used in attempts to control the insect but with little success. The use of insecticides has reduced pest numbers for limited periods but has resulted in damaging effects on other components of the environment. An effective pest population management system must integrate use of the various natural control organisms with artificial control methods to achieve optimal control of gypsy moth populations with minimal adverse effects on the environment. Approaches to this objective are described. NE (755).

239. Research on methods of controlling the gypsy moth has centered at times on a wide variety of approaches. New insecticides and methods of application have been developed; exotic parasites and predators have been imported, mass-reared, and released; male annihilation techniques have been investigated; attractants have been identified, synthesized, and field tested, and environmental manipulation has been attempted. It is now evident that we must develop systems of pest management based on manipulation of the real-life processes that do in fact regulate gypsy moth numbers. Research and development efforts will involve the development of effective methods of measuring and assessing population changes and integrating this knowledge with proven manipulative techniques to manage gypsy moth populations. NE (754).

240. Intensive forest management practices are changing the role of known forest insect pests and creating new problems involving other insects previously considered innocuous. In the Douglas-fir and western hemlock stands of the West, damage by tree-killing insects in old-growth stands is gradually shifting to insect problems affecting stand establishment and management of second-growth stands. This will pose a challenge to pest management specialists and forest managers in the near future. PNW (756).

241. Forests provide a unique opportunity to develop truly sound and effective strategies to manage the insect pests that adversely affect productivity, value, and usefulness. Different economic and sociological values placed on forests pose an unusual challenge in determining what are the really critical pests and how, when, and where to take action against them. Both ecological and economic thresholds must be established for each pest, or pest complex, and these are not static in time or place. WO (757).

9. ROOT DISEASES

a. Annosus root rot

242. An up-to date bibliography of world literature on annosus root rot has been compiled. The bibliography supplements an earlier one

covering work up to 1960 and covers the period 1960-1970 adding nearly 600 new titles. SE (413).

243. A common wood inhabiting fungus, Peniophora gigantea, effectively controls annosus root rot in southern pines. Techniques have been developed for commercial production of inoculum and operational application during thinning operations. (426, 427).

244. The spread of annosus root rot in thinned shortleaf pine plantations in Missouri was studied over an 8-year period on plots established in 1963. Mortality from the fungus has declined since 1965, but the decline has been more rapid since 1968. NE (409).

b. Poria root rot

245. Biological control of Poria root rot and improvement of genetic resistance can be advanced by understanding the biochemical nature of host resistance and susceptibility. Natural chemicals associated with resistance or susceptibility were identified in the roots of red alder and Douglas-fir. These and other compounds probably account for relative resistance of red alder to the disease. PNW (415).

246. Poria root rot may be controlled by antagonistic soil microorganisms. Urea and wood shavings, incorporated in potted forest soil, greatly increased numbers of these soil fungi. One species of Trichoderma which was increased by addition of urea under laboratory conditions was highly antagonistic to the Poria root rot pathogen. PNW (422).

247. Evaluation of the impacts of forest diseases may best be accomplished with the aid of aerial surveillance. Remote sensing techniques have been developed which permit identification of Poria root rot centers in the Douglas-fir-western hemlock forests. PSW (435, 436).

c. Nematodes

248. Lance nematodes parasitize and damage roots of the Ocala race of sand pine in west Florida sandhills. The Choctawhatchee race of sand pine is now being planted instead of the Ocala race because of its apparent resistance to Clitocybe root rot. Greenhouse studies on seedlings indicate neither race of sand pine is resistant to lance nematodes. SE (430).

249. The parasitism and pathogenicity of several species of nematodes were tested on red maple, sweetgum, yellow-poplar, American sycamore, and swamp cottonwood. Some trees suffered severe root damage. These studies suggest that some hardwood plantings may fail, particularly if planted on agricultural lands infested with nematodes parasitic to agronomic crops. SE (410, 428, 429).

250. Nematodes feed and reproduce on several species of mycorrhizal and plant pathogenic fungi. The nematodes had no effect on viability of a number of the fungi, but some failed to revive when transferred to a

fresh, artificial medium. Fungus-feeding nematodes have the potential to reduce or inhibit pathogenic or mycorrhizal fungi under natural conditions. RM (425).

d. Mycorrhizae

251. Techniques are being developed and improved to classify and culture mycorrhizal fungi. The role of mycorrhizae as biological deterrents to root disease is now better understood. Studies have provided needed information in understanding the role of these important organisms in forest ecosystems. Artificial inoculation of seedlings with selected mycorrhizal fungi will reduce root disease losses and possibly permit regeneration of severely disturbed sites such as strip mine spoils. PNW (432, 439), FPL (423), SE (416).

252. Host genotype significantly influences mycorrhizal development. Some progenies of slash pine showed marked differential susceptibility to infection by mycorrhizal fungi. These findings may explain growth differences between progenies of pine planted on different sites where different mycorrhizal fungi are present. SE (420).

253. The occurrence or function of endomycorrhizae on trees is poorly known. Techniques were developed to form certain endomycorrhizae on the roots of citrus species. These studies will provide needed information to explore endomycorrhizal development on other tree species, particularly hardwoods, so their function and importance can be determined. SE (421).

254. A system for classifying mycorrhizae of Douglas-fir and identifying their fungal component has been developed. A tuberculate mycorrhizae was found which was antagonistic to pathogens causing annosus, Poria, Pythium, and Phytophthora root rots. Using the new system, ecological requirements of this and other mycorrhizal fungi may be readily determined and their potential in biological control of root disease evaluated. PNW (440).

255. A new root protecting function of mycorrhizal fungi has been discovered. An ectomycorrhizal fungus deactivates soil toxins that severely aborted root growth and stunted Douglas-fir seedlings without mycorrhizae. Mycorrhizal fungi probably aid tree growth in nature by protecting feeder roots from soil toxins. PNW (438).

(For an additional item relating to II B 9d see paragraph 250.)

e. Miscellaneous root diseases

256. Environmental stress and defoliation of sugar maple causes a change in the chemical constituents of the roots. Extracts from the roots of defoliated trees significantly increased growth of the Armillaria rot root pathogen. The studies suggest that environmental stress and defoliation of trees by insects may predispose them to Armillaria root rot. NE (424, 433, 434).

257. Mortality from Armillaria root rot in ponderosa pine plantations in New Mexico was inversely related to tree height. These findings suggest that this root rot may significantly affect early survival of ponderosa pine in New Mexico plantations. RM (437).

258. A serious, new root and butt rot of deodar cedar caused by Peniophora has been discovered in India. The previously unknown disease causes heavy losses in deodar plantations. WO (408).

259. A new species of Pythium was isolated and described from dead feeder roots of declining loblolly pine in the Gulf Coastal Plain of Louisiana. Other species of this fungus are serious root pathogens, but the relation of this species to declining pine in Louisiana is not fully understood. SE (411).

260. Several species of Phycomycetous fungi including a number of serious feeder root pathogens, were isolated from soil collected in old growth forest sites in Kentucky, Tennessee, and North Carolina. The studies suggest some species are indigenous and not widespread or did not survive conversion from forested to agricultural land. Other species are found commonly in both areas suggesting their ability to adapt to agricultural habitats. SE (412).

261. Phytopthora root rot causes significant losses in Fraser fir Christmas tree plantings in western North Carolina. This species is highly susceptible to Phytophthora root rot and should be replaced by white or Scotch pine where infested soil occurs. Fraser fir should not be planted in poorly drained or former shortleaf or loblolly pine sites. SE (414).

262. The littleleaf disease caused by Phytophthora root rot has prevented successful regeneration of shortleaf pine on certain sites in the southeastern United States. Growth and condition of geographic sources of shortleaf pine were evaluated after 16 years on three littleleaf disease sites in the Piedmont region. Results indicate shortleaf pine can be selected for adaptability to disease sites. SE (431).

10. STEM CANKERS

a. White pine blister rust

263. An international test program proposed by the IUFRO Working Party for Resistance of White Pines to Blister Rust includes reevaluation of naturally resistant white pines from near the original white pine blister rust pathogen gene center followed by sophisticated testing of North American white pines developed for resistance. Key test centers are proposed in Siberia, south-central Asia, the North Sea-Baltic Sea countries, and eastern and western North America. INT (442).

264. Recent studies show the white pine blister rust fungus grows normally in some western white pine needles until it reaches the short shoot. At this point, a resistance mechanism is triggered causing the host cell and fungus to die, thus preventing normal canker development. Such natural resistance mechanisms may be useful in breeding trees resistant to white pine blister rust. INT (453).

265. Western white pines from crosses of parents selected for resistance to white pine blister rust were examined for infection after 11 to 15 years in two areas. Progenies with general combining ability for resistance transmission were 20% infected compared to 58% infection in controls and 71% in natural reproduction. Although resistance to white pine blister rust is not complete, there is sufficient resistance to start planting of first-generation nursery stock. INT (463).

266. Great progress has been made in determining the nutritional requirements and growth regulating compounds of the white pine blister rust pathogen by studying host and nonhost tissue cultures inoculated with the pathogen. Development of such techniques clarifies the host-parasite relationships and provides the basis to develop effective chemical controls and understand mechanisms of resistance necessary to manage this destructive pathogen. (INT (447, 448, 449, 450, 458).

267. Low temperatures reduce the potential for production of pine-infecting spores of the white pine blister rust. Reductions in inoculum potential is almost in direct proportion to decreases in temperature from 60° to freezing. This finding suggests that low temperatures and a minimum of late-summer, moist periods reduce the hazard of rust infection to high-elevation white pine forests in the central Rocky Mountains. INT (456).

b. Fusiform rust

268. Alternate hosts for fusiform rust and eastern gall rust are similar. On the pine host, they cannot be distinguished morphologically. A new technique permits distinction between aeciospore collections of the two rust pathogens and provides invaluable identifications of inoculum used in screening pine seedlings for rust resistance. SE (445).

269. A technique was developed to patch graft fusiform rust and eastern gall rust infected tissue onto healthy seedlings. This study showed that the pathogen does not determine the shape of the gall, but that host response to the pathogen may be the governing factor. SE (459).

270. Different levels of fusiform rust resistance have been found in open-pollinated progency of loblolly pine. Resistant progency consistently had less infection than ordinary open-pollinated progeny not selected for resistance. This discovery is the first step in identifying resistance in loblolly pine. Screening seedlings for rust resistance is now feasible. SE (461).

271. Meteorologists can accurately predict weather that favors fusiform rust infection of southern pine seedlings in nurseries. Infection hazard forecasting for nurserymen will permit them to reinforce their regular spraying schedule with special applications. SO (444).

c. Other tree rusts

272. Loblolly and shortleaf pines are very susceptible to comandra rust in eastern Tennessee; Virginia and pitch pines, however, are less susceptible. Results of one study suggest that where heavy losses are sustained in planted susceptible species, alternative resistant species should be considered in replanting. SE (460).

d. Other cankers

273. The growth rate of some canker-producing fungi is increased by fluctuating temperatures. Actual growth rates of such organisms cannot be accurately predicted if constant temperatures prevail in the experiments. NE (454).

274. Ceratocystis and Diplodia canker were found in American sycamore plantings in the southeastern United States. The pathogens are extremely virulent in young sycamore plantings. Since the organisms normally enter through tree wounds, precautions are necessary to avoid losses from these pathogens in managing plantations. SE (462).

275. Natural regeneration of yellow birch in Wisconsin and Michigan is hindered by cankering, stem dieback, leafhopper oviposition wounds, and animal browsing. A number of canker-producing organisms have been associated with the problem, but further studies are required to determine their role. Serious suppression of yellow birch regeneration will occur if the problem is not checked. NC (455).

276. Ceratocystis canker is widespread throughout the western United States on aspen, frequently causing extensive stem damage which must be culled. Recent studies have positively identified the pathogen and described the disease process. Nitidulid beetles have been identified as vectors of the pathogen. This information provides a basic understanding of the disease process and may give useful leads for control. RM (451, 452).

277. Septoria canker has been found on eastern cottonwood seedlings in Mississippi nurseries. Presence of the disease poses a problem for nurserymen propagating cuttings of cottonwood for clonal nurseries or commercial plantations. SO (446).

11. DWARF MISTLETOES

278. A taxonomic revision of dwarf mistletoes of the world has been prepared in which 32 taxa are recognized. Host relationships, evolution,

distribution, criteria for classification, and collecting techniques are discussed in the 234-page book. The distribution maps, keys, and color and black and white illustrations make it a valuable tool for students, scientists, and practicing foresters. RM (466).

279. Cooperative studies between the Forest Service and universities, and other Federal agencies have produced important findings on the physiology, cytology, evolution, and insect associations of dwarf mistletoes. RM (469, 471, 474).

280. A computer program has been developed to compute yield tables for dwarf mistletoe-infected lodgepole pine in Colorado and Wyoming. This procedure provides foresters with the first practical tool for making decisions in managing timber where this destructive parasite is present. RM (470).

281. An illustrated glossary containing 260 dwarf mistletoe terms has been prepared. It will be a useful tool for researchers and dwarf mistletoe control personnel. RM (465).

282. Research sponsored in the western Himalayas has shown that dwarf mistletoes cause a serious economic loss in blue pine. The parasite, its distribution, and control are described. WO (464).

283. Studies of dwarf mistletoe seed dispersal in Jeffrey pine were conducted in California. Seed production and distance of spread were determined. Storms may aid in dispersal and considerable variation may occur in numbers of seed produced from year to year. PSW (472).

284. Control studies in ponderosa pine stands show dwarf mistletoe was not eliminated after 10 years, even with yearly sanitations, because of latent infections in the remaining tree crown. Results suggest silvicultural control of dwarf mistletoes will be most successful where infection is very low. PNW (473).

285. PL 480-sponsored scientists in India are investigating enzymes and their inhibitors in mistletoes. Certain types of enzymes may play a role in the process of parasitism and absorption of carbohydrates from the host. This information may lead to chemical or genetic control of these parasites. WO (467, 468).

12. VASCULAR WILTS

286. Techniques have been developed to solubilize the fungicide benomyl for injection into elm, oak, and maple. This breakthrough gives new hope that destructive vascular wilts such as Dutch elm disease, oak wilt, and Verticillium wilt can be controlled. NE (477, 479, 480).

287. Studies have been conducted on the transpiration, vascular water flow, and pathogen isolation in oak wilt-infected trees. Results of these studies have provided a basic understanding of the movement of fluids in vascular diseased trees. NE (475, 476).

288. Attempts to control fungus mat formation and oak bark beetle vectors in oak wilt-infected trees in the Northeast by treating with the herbicides, 2, 4-D, and cacodylic acid or tree felling were not successful. Different approaches are necessary to control the long-range spread of oak wilt. NE (481, 482).

289. Programs to control oak wilt in Pennsylvania and West Virginia have produced inconsistent results. These findings will provide a basis for decisions to continue, alter, or terminate oak wilt control programs in both States. NE (478).

13. FOLIAGE DISEASES

290. Spore trapping studies show that spores of the brown spot needle blight fungus are produced throughout the year in the South. Greatest quantities occur from April through August and coincide with new flushes of needle growth. Additional research is needed to clarify the role of temperature-moisture interactions in the infection process. SO (485).

291. A widespread needle blight of slash and loblolly pine in 1970-71 in six Southern States has been attributed to three fungal pathogens. Although slight growth reduction has probably resulted from infection by these pathogens, little or no mortality has resulted. Direct control with fungicides does not appear to be warranted. SO (484).

292. In 1970. Dothistroma needle blight in Minnesota rendered many Austrian pine Christmas trees unsalable. Severe defoliation of trees up to 8 years old resulted in mortality. The disease can be controlled by chemicals but the economic feasibility is questionable. Trees genetically resistant to the needle blight, may offer the best solution. NC (486).

298. Diplodia shoot blight has recently caused serious damage to Austrian, Scots, and ponderosa pine in the central Great Plains of the United States. Basic information on spore dispersal, germination, and the infection process has been determined. Study results indicate protection by fungicides is required to avoid serious losses. RM (483).

294. An outbreak of the Lophodermium needle cast fungus is causing serious defoliation of Scotch pine Christmas tree plantings in 11 States and British Columbia. Studies indicate the fungicide maneb will control the disease. NC (488).

14. AIR POLLUTION DAMAGE

295. Studies show significant variation among hybrid poplars in tolerance to SO_2 fumigation. Where possible, clones tolerant to short-term exposures of high levels of SO_2 should be selected for planting where air pollution may be a problem. NE (490).

296. The photosynthetic response of red maple seedlings fumigated with SO_2 is being studied, Information from these studies is essential in calibrating host response to pollutants, understanding the mechanism of pollution damage, and predicting the tree's potential for removing certain pollutants from the air. NE (494).

297. Study of ponderosa pine needle tissue fumigated with ozone showed that the destruction of chloroplasts was the first damage. Associated changes in the needle chemistry were decreases in carbohydrates and disruption of proteins and nucleic acids. PSW (491).

298. The incidence of oxidant air pollution damage was investigated in 8 air basins in California. Ponderosa, Jeffrey, Coulter, and Monterey pines and bigcone Douglas-fir were most severely damaged. The study indicates there is potential for more extensive damage to mixed conifer forests of the Sierras. PSW (493).

15. DETERIORATION OF WOOD

299. Engelmann spruce may now be effectively managed to avoid decay. Studies suggest that decay in young stands in the future will be negligible if wounding is minimized during silvicultural operations. PNW (495).

300. Single basidiospores isolated from some wood-rotting fungi can form fruiting bodies and viable spores in culture. Studies were conducted to examine this phenomenon cytologically and determine its significance in the decay process. SO (496).

301. The production and role of extracellular hydrogen peroxide is being studied in certain wood-rotting fungi. Important findings suggest this chemical may be involved in plant pathogenesis and degradation of plant constituents by wood-destroying fungi. SE (509, 510).

302. The rapid invasion of southern pine logs by stain and decay fungi after cutting has caused serious problems in handling, storage, and utilization. Recent studies suggest that while there may be some loss in noncellulose components of the wood, storage under continuous water spray is an effective way of preventing these problems. SO (500, 501, 512).

303. For the first time, an annotated bibliography is available on the prevention and control of decay in wooden structures, including boats. This compilation will be a valuable aid to wood technologists and pest management specialists. SO (497).

304. Techniques have now been developed which promise extended serviceability of exterior woodwork. Long-term studies in diverse climates covering periods up to 19 years indicate dip preservative treatment of wood for exterior use will materially extend its usable life. PNW (511), SO (518).

305. A new obligate anaerobic bacterium has been isolated from stained wood tissue in living hardwood trees. Further research is required to determine the significance and function of this organism in the stain and decay process. NE (516, 517).

306. Wounds in trees initiated the sequence of events that lead to discoloration and decay. Studies now show that certain chemicals may retard the development of discoloration in wounds on red maple. NE (506, 507).

307. Studies are being conducted on the succession of microorganisms and patterns of discoloration and decay after wounding in red and white oaks. Results of these studies will provide a basic understanding of these processes and, perhaps, lead to means of preventing losses. NE (515).

308. Standard methods for testing natural resistance of wood to decay have been improved. A new technique provides a more accurate evaluation of wood decay and has led to the adoption of a new American Society for Testing and Materials (ASTM) standard for determining the natural durability of wood. FPL (504).

309. Little information is available on service records of laminated wood used in ship construction. Inspection of wood minesweepers after approximately 15 years' service revealed negligible decay. Results suggest wood components of similarly constructed ships will remain serviceable for several years. FPL (505).

310. Different methods of determining loss of wood substance caused by fungal attack in pulpwood chips stored outdoors have been evaluated. Results have shown the specific gravity method is an accurate and reliable technique for determining fungal degradation in stored pulpwood chips. FPL (502, 503).

16. FOREST FUNGI

311. Forests are an association of countless numbers of organisms. As we strive to protect and wisely manage complex forest ecosystems, serious voids in our knowledge of microorganism occurrence and function must be filled. Recent studies by Forest Service scientists throughout the United States have contributed to our understanding of forest fungi. Monographs have been prepared on several genera of fungi. The occurrence and ecological functions of a number of new species of fungi have been recorded. Important, new mycorrhizal fungi have been identified and their probable functions described. Information derived from these studies will

provide possible new leads to such things as biodegradation of forest residues, nutrient recycling, regeneration of severely disrupted sites, and biological control of forest pathogens. FPL (525, 527, 528, 529, 537), SE (522, 526), RM (521), PNW (524, 532, 533, 534, 535, 536).

312. Fungi representing 30 genera were isolated from fruit and seed of northern hardwood trees. Further research is required to determine their importance in seed storage and germination. NE (523).

313. PL 480-sponsored research in Pakistan has generated valuable information on new fungal records of white mulberry and Ganoderma root rot of sissoo. Effective control of these tree pathogens may now be accomplished. WO (519, 530).

314. PL 480-sponsored disease research in India has revealed a number of new diseases of exotic conifers and hardwoods. Early study and identification of these problems, some with international significance, will lead to effective control before serious epiphytotics occur. WO (520, 531).

17. MISCELLANEOUS STUDIES

315. The pathology of forest and shade trees of the United States has been compiled in one book. This unique 658-page publication is organized by the host attacked instead of by causes of the disease. A short description of silvical characteristics of each host species is followed by sections on seedling, foliage, stem and root diseases, trunk rots, mycorrhizal relations, and miscellaneous pathology. This monumental reference book will be an invaluable aid to students, researchers, and pest management personnel. WO (543).

316. Sirococcus tip blight was reported for the first time in California tree nurseries. The disease on Jeffrey pine can be effectively controlled by chemical fungicides. PSW (562).

317. Seedling mortality after outplanting is a constant problem when regenerating extensive areas. Scientists are investigating root pruning as a way to improve root systems of Douglas-fir and reduce seedling losses in plantations. PNW (564).

318. Diseased trees presently pose hazards in recreation areas because of breakage or windthrow. An analysis of factors involved in recreation site hazard has been completed. A guide now is available for rating hazard and making control decisions in recreational areas. PSW (552).

319. Climate profoundly influences the growth of forest trees. In recent studies, pole blight of western white pine has been associated with a 24-year period of severe moisture stress. Unless an unfavorable climatic shift reoccurs, pole blight is not expected to be a problem again for several centuries. INT (550).

320. Mycoplasma-like bodies have been associated with the phloem necrosis disease of American elm which is epidemic in some parts of the United States. If mycoplasms are the cause of phloem necrosis, originally attributed to a virus, the possibility exists that antibiotic treatments will control the disease. NE (572).

321. Recent studies have shown that crown gall of hybrid poplars may be controlled by applying antibiotic solutions to stem tumors NE (545).

322. Dieback and decline diseases are often initiated by environmental stresses including drought and temperature extremes. Effects of stresses are not well understood, but studies show that the most drought-resistant trees were also the most heat resistant. In addition, an unusual structure has been found in conifer needles which may explain drought resistance in some tree species. NE (554).

323. A number of technological advancements have been made in germ-free plant research. Methods for seed sterilization, certification of seedlings as germ-free, and maintaining tree seedlings in a sterile environment have been developed. No ill effects were observed when a number of green plants were grown in the presence of lunar materials returned by Apollo 12, 14, and 15 missions. These findings are further evidence that lunar materials pose no hazard to living systems on earth. SO (538, 547, 549, 565, 566, 567, 568, 569, 570, 571).

324. Mistblower applications of the fungicide Ferbam, successfully protected artificially inoculated slash pine strobili from infection by southern cone rust. This technique may be useful in protecting slash pine seed orchards from heavy losses caused by cone rust. SE (540).

C. Accelerating Forest Resource Surveys

1. FOREST INVENTORY

Sharp increases in timber demands for residential constructive have again caused concern about the adequacy of the Nation's timber supply. In a continuing effort to provide current information for timber supply analysis, field surveys were conducted in Alabama, Alaska, California, Connecticut, Georgia, Hawaii, Missouri, New Jersey, New Mexico, Oregon, South Dakota, and Tennessee. Reports appraising the forest resource situation were issued for eight States or portion of States. Approximately 45 million acres of commercial forest land were re-inventoried during the past year. At this rate the resurvey cycle averages 11 years.

325. Florida's forest area declined 5 percent between 1959 and 1970 because of diversions to agriculture, urban and other users. Meanwhile, timber volume increased from 9.1 to 10.9 billion cubic feet, or 20 percent, despite the reduced area base. About 79 percent of this increase was in softwoods.

In 1969, net growth exceeded timber removals by 184 million cubic feet, or 53 percent. The higher inventory is manifested by a reduction of nonstocked forest land from 6.9 to 2.6 million acres. Area planted averaged over 200,000 acres annually. About 2.0 million acres, or 12 percent of the commercial forest lands, have been artificially regenerated between 1959 and 1970. SE (99, 100).

326. The trend toward less forest land was also detected in the Delta Region of Arkansas, Southeast Georgia, Northern Michigan, East Tennessee, and Wisconsin by recent surveys. NC (92), SE (87), SO (94, 102, 103).

327. In Maine where forest industries own 49 percent of the commercial forest land, forest area increased 3 percent between 1959 and 1971. A general trend in the East is illustrated in Maine by a 23 percent gain in growing stock volume. Annual growth for 1970 was 711 million cubic feet, well above removals of 409 million cubic feet, although more white pine, northern white cedar, yellow birch, and sugar maple sawtimber is being harvested than grown. The largest increases in volume occurred in spruce and balsam fir, both major pulp species. NE (93).

328. The southern forest resource is rapidly changing. Because of the 10-year interval between statewide surveys, available forest resource information is often neither current nor detailed enough for local needs. In a test to expand the utility of forest survey statistics, a computerized system for annual updating of basic data was developed. The updating system, incorporating timber growth and removals estimates, was used to produce current resource and production statistics for the 370 counties in 6 southern states. SO (88).

2. TIMBER UTILIZATION AND PRODUCTION

329. Efficiency of timber utilization was investigated in the Northeast and Pacific Coast regions of the U.S. Nearly one-fifth of the timber harvested in the Northeast was lost in the process of converting to products. Eighty-five percent of this was left as logging residue in the woods. Much of the plant residues were salvaged, primarily for pulpchips.

In the Pacific Coast region, logging residues have trended downward from 23 percent of the harvest in 1952, to 15 percent today. Manufacturing residues have increased in recent years, but a higher proportion is now being remanufactured into useful byproducts. PNW (115, 116), NE (113).

330. A study of pulpwood production and utilization in the South Central States shows that average hauling distance has remained substantially the same since 1960. Pulpwood production in the South continued upward in 1970 reaching a peak of 42 million cords. A significant departure from past trends are recent gains in the use of oaks and other hard hardwoods for pulping. SO (104, 106).

331. Pulpwood procurement patterns analyzed in the Northeast reveal considerable change in recent years as old, inefficient mills close or convert to new pulping processes, and high-production mills open. Pulpwood production rose 11 percent over the previous year. NE (114).

332. In the North Central States, pulpwood production also reached a new high, spurred by marked advances in both pine and birch. The use of paper birch signifies an important development in pulping technology that will add to the utility of this widely available species. NC (107).

333. Pulpwood prices were reported for both the Southeast and South Central regions. Although modest gains were observed in 1970, relative prices actually declined. Differences still prevail between the two regions with eastern prices averaging more than $1 per cord more for pine. Hardwood prices are only slightly higher in the East. SE (120), SO (105).

334. Sawlog production in Kansas and Iowa was highlighted by two reports from the North Central Station. Important species common to both States are cottonwood and elm. In these States, very little of the wood residue from sawmilling is used. NC (111, 112).

335. Veneer manufacture was analyzed in the North Central, Southeast, and South Central regions. Throughout the East, hardwood veneer production is gradually declining. In the last decade, however, large scale expansion in the manufacture of southern pine plywood has drastically altered the industry. In the South Central region where plywood plants are concentrated, a fivefold increase in veneer output occurred between 1963 and 1970. NC (117), SO (122), SE (126).

3. SURVEY TECHNIQUES

336. Site-index comparisons were developed for quaking aspen, paper birch, basswood, red oak, black ash, jack pine, red pine, white pine, white spruce, black spruce, balsam fir, and tamarack in northern Minnesota. Knowledge of site index relationships among species is necessary for rating site potentials in major forestry treatments such as type conversion. NC (127).

337. Accuracy of standing-tree volume estimates using the McClure Mirror Caliper, an optical dendrometer, was tested by comparing standing tree volume estimates with measurements after felling. The results demonstrate that the Mirror Caliper estimates are within 2 percent of the felled tree volume check. SE (128).

338. A case study using two Arkansas Forest Survey regions incorporated a functional forest resource appraisal. This approach combines the timber inventory, with sources of relevant information about other functions such as recreation, to overcome deficiencies in appraisals that deal solely with timber production. SO (131).

(For additional items relating to II C 1 see paragraphs under III A 7; to II C 3, see under II C 1.)

D. Economics of Forest Management

1. METHODS OF FINANCIAL EVALUATION AND PLANNING

339. Capital budgeting techniques have been developed for ranking investment alternatives for which the rate of return varies with the amount invested. The technique proposed develops a new type of capital demand schedule that aggregates the marginal rate-of-return curves of individual projects. This leads to a greater investment in projects promising the highest rate of return, and results in a more efficient allocation of capital. NC (4).

340. A new computer program for discounting benefit and cost flows over time interpolates values for years for which no data are supplied and permits combining flows of differing lengths. Outputs of the program include discounted present values of individual costs or benefits, and summed net present value for an entire project. RM (2).

341. Computer-prepared tables present 10 selected compound-discount interest rate multipliers commonly used in financial analyses of forestry investments. The first set of tables gives multipliers for each year from 1 to 40 years; the second set gives multipliers at 5-year intervals from 5 to 160 years. Multipliers are given for 24 selected interest rates from 0.5 to 30 percent. NC (6).

342. In a comparison test with two traditional techniques of forest control and regulation, a new computerized planning system called Timber-RAM allows a more realistic definition of timber resources and and can analyze a wider spectrum of forest management practices. The traditional methods using linear programming are simpler to apply and less expensive. Inventory data from a National Forest in California served to illustrate how each technique is used. PNW (3).

2. TIMBER GROWING ECONOMICS

343. An operational version of Timber-RAM (Resource Allocation Method) provides a long-range planning tool for commercial timber lands under multiple-use management using linear programming techniques. Timber-RAM can produce cutting and reforestation schedules and related harvest and economic reports for an area the size of a National Forest over several rotations. Each schedule optimizes an index of performance, subject to periodic constraints on revenues, costs, and harvest levels. Constraints can also be used to regulate forest stands and to even out the flow of timber during conversion. PSW (17).

344. Guides for investors considering removal of low-value stands to establish pine plantations indicate financial returns for various levels of expenditures, and for separate species, site indexes, different levels of costs and prices. Both immediate conversion and delayed conversion,

with and without timber stand improvement are considered. Opportunities for forest type conversion exist on 50 million acres, and occur in every ownership class. SO (8).

345. Rates of value increase developed for 10 species common to the oak-hickory type are useful for evaluating individual trees, and for evaluating future diameter growth, increase in merchantable height, and improvement in tree quality in stands. The method is applied to all forest-management techniques. The rate of value increase is the measure that, combined with basal-area requirements of silviculturists, provides a more adequate base from which to determine what to cut. NE (9).

346. Simulation techniques were successful in determining the cost, yield, and price conditions which would make silage-sycamore profitable and in indicating areas where additional research and refinement are necessary. Costs of establishing and maintaining silage-sycamore plantations were found to be extremely high relative to other forest species, eliminating silage-sycamore as a profitable land use for independent growers who wish to market the crop as stumpage. Industrial landowners may compensate for these costs if they purchase specialized equipment and plant large acreages. SO (10).

347. A survey of forest industry firms provides current estimates of the costs of practicing forestry in the South and depicts cost changes and trends for the period 1952-67. Eleven major practices are analyzed in detail: controlled burning, seeded preparation by bulldozing or disking, planting open land by hand and by machine, planting cutover land by hand and by machine, cutting to release young growth, poisoning undesirable trees, girdling undesirable trees, cruising, and marking trees for harvest. Costs increases varied from 200 to 700 percent over the 15 years, exceeding the inflation in the general economy and in prices received for forest products. SO (15).

348. For purposes of the Federal income tax there are two types of logging roads--permanent and temporary. The tax status of permanent road costs is relatively clear. There is substantial legal confusion as to whether temporary roads can be treated as business expenses, or should be capitalized as a cost of the timber. The controvery has been described in detail, as well as other tax aspects of logging roads. SO (13).

3. MULTIPLE-USE ECONOMICS

349. The area of forest land now considered suitable and available for sustained timber management on six western National Forests is about one-fifth less than previously reported. The reduction in area estimates reflects more precise consideration of land productivity, land instability, isolation of small stringers and patches of forest land, and impacts of improved multiple-use planning. Revised classifications of forest land in terms of planned use contributed most to the reduction of areas classed as commercial forest land. Impacts on allowable cut will be less than the reduction in area. INT (18).

350. Timber and water response data from studies of watersheds at the Fernow Experimental Forest provide an approach for evaluating streamflow increases in terms of value of timber growth foregone. Light cutting slightly increased values of both timber growth and streamflow. Cutting three-fourths or more of the forest vegetation provided major increases in streamflow but no return from timber during the 10-year period of regrowth. Average annual water costs ranged from 0 to $1.30 per thousand gallons. NE (19).

351. Concern for the environment has all but bypassed considerations of ground-water pollution. The opportunity cost of replacing ground water with alternative sources imparts a very high value to the resource. Though gound water is generally less vulnerable to pollution than surface water, this lower susceptibility is swamped by the consequences of ground-water contamination. The time required for a sizable aquifer to become contaminated is negligible compared with the time required for the system to flush itself of the pollutant. RM (16).

4. IMPACTS ON FOREST INDUSTRY AND REGIONAL ECONOMIES

352. Owners of large forest acreages sell forest products more frequently, undertake forest management more often, and are more interested in income producing potential of their forest tracts than owners of small tracts. A sample of nearly 400 owners in 3 different areas of Pennsylvania provided information to develop a sound basis for assessing the role of individual woodland owners as suppliers of forest products and services. Most of the owners said they have not obtained information about management and marketing of forest products during the past 5 years. Only a very small percentage of all the owners entered into formal government programs. NE (26).

353. Analysis of output-per-man-hour data for 1947-67 indicates that productivity rose for all major forest products industries at an average annual rate of 3.3 percent. Particularly remarkable was the substantial improvement in the lumber and wood products sector whose productivity increased annually by 3.2 percent, about the average for all manufacturing. Actual employment, however, dropped 14 percent. Another major increase was in the paper industry whose productivity increased at an annual rate of 3.4 percent. SO (24).

354. Forest industry in the South appears to be gaining progressively in its competitive position relative to the same industries in other regions or the nation as a whole. In the South, forest-based industries can be categorized as rapid-growth components of the region despite slow growth patterns nationally. The South is gaining markets for forest products due to shifting nonforest industries and populations, a relative gain in resource availability, and recent technological innovations in forest-product processes that have altered input that favor smaller trees. SO (25).

355. A regional location model has been shown to accurately predict the direction of regional shifts in plywood and lumber industries that have taken place in the last 5 years. Recent movements in regional stumpage prices, however, do not agree with those projected by the model, probably because the model assumes regional stumpage markets are equally competitive and all species are perfect substitutes in production and consumption. If these assumptions are more nearly true in the future, long-run relative increases in southern pine stumpage prices are likely. SO (23).

E. Improving Engineering Systems

356. Both balloon and skyline systems of harvesting have proven their effectiveness for harvesting timber in mountainous areas. Each system has its advantages and disadvantages. A new system combining the two is now under consideration. Preliminary considerations indicate the new system would approach the ideal by combining the best features of both while minimizing the disadvantages of each. If the results of planned operational tests are favorable, an economical method will be available for logging long spans in swampy forests and appropriate difficult-to-log mountainous terrain. PNW (780).

357. Today's widespread concern for the environment necessitates reorientation of the economic analyses and methods used to determine forest road locations and standards. Presently, we lack much of the data needed for total analysis and planning for truly optimum forest road systems. Certain information and means are available, however, that emphasize environmental quality protection. A procedure that might be considered to help decide on appropriate locations and standards, until better data are available, has been developed. INT (770).

358. The woods labor force, relied on heavily by the gum naval stores industry, is steadily diminishing. It may be necessary eventually to collect gum by a system requiring little or no labor. A cooperative study between the Forest Service and a private operator has resulted in a pilot operation employing commercial laborers and the first fully mechanized pine gum harvesting system in the United States. Results were encouraging, though production rates were low. No major obstacles to further development of the system were evident. SO (767).

359. An efficient and economical system for segregating bark and wood chips will greatly enhance possibilities for broader use of logging residues. A system involving air flotation to accomplish the separation is a unique possibility and information on the terminal velocity of the two materials, basic to design of the system, has now been developed. Preliminary research results show a significant difference between terminal velocities of aspen wood and bark chips, thus making air flotation a promising segregation method. NC (784).

360. Training programs for novice wheeled-skidder operators are usually unavailable at most Appalachia logging operations. Untrained operators are inefficient, sometimes a safety hazard, and can contribute

to ecological damage. Experimental test experience has disclosed many techniques necessary for efficient operation of that type of machine involving such areas as bunching logs, load selection, loaded and empty travel, blade use, preventive maintenance, and the like. The information presented can be used as a training tool to develop skilled logging machine operators capable of providing efficient, safe, and ecologically improved logging. NE (776).

361. The running skyline system, a logging system using two or more suspended moving lines, is being used by an increasing number of timber operators. A procedure using a desktop computer/plotter can be employed to plot terrain profiles, ascertain and plot the path of running skyline carriage, and determine running skyline load-carrying capability over a given ground profile, as shown by a recent study. Computer programs for implementing the procedure have also been developed. The information is useful to the logging system designer who is investigating application of running skyline systems in his harvesting plans. PNW (766).

362. Logging balloons, in a range of sizes, are operated in a variety of atmospheric conditions. Fundamental principles of aerostatics and thermodynamics can be used to compute influence of these conditions on gross static lift. A report on recent studies establishes parameters influencing static lift, shows how it can be computed, and provides nomographs for field computations based on pressure, temperature, and volume values. This provides the balloon logger with the information required to calculate changes in lifting potential as operations and environmental conditions change. PNW (765).

F. Improving Water Quality and Yield

1. IMPROVING WATER YIELDS

a. Vegetative manipulation

363. During the first 2 years following chemical treatment of trees and shrubs along well-defined stream channels of a 246-acre chaparral-covered watershed in Arizona, both duration and volume of streamflow increased. Streamflow, which was usually intermittent during summer and fall, became continuous and yielded increases of 32 and 54 percent for 1968 and 1969, respectively. RM (226).

364. Cutting along mid-contour lines on forested watersheds on the Fernow Experimental Forest established that quantity and timing of yield was little influenced by the site of cutting. When the upper half of one watershed and the lower half of an adjacent one were maintained barren for 3 years, annual flow increases on each held close to 6 inches. Flow increases rose to 10 inches annually after both watersheds were completely deforested and kept barren. NE (234).

365. Long-term average water yield of a watershed appears to be a good index to the magnitude of its expected peak flow, and on the basis of this criterion, tables were prepared showing expected peak flows that are applicable to watersheds in Idaho and Montana. The tables may be used to help solve problems on effects of clearcutting operations, channel stability, bank cutting, and stream level. INT (212).

366. Conversion of forest land to urban uses in the Northeast will likely produce increases in water yield, storm runoff, and sedimentation, with the latter resulting primarily from construction. However, under certain circumstances, partially urbanized watersheds may produce lower peak flows and require longer periods to discharge equal amounts of water than forested watersheds. Forested areas within larger cities may be useful for disposal and renovation of waste water, groundwater recharge, and soil stabilization. NE (231).

367. A study in the Northeast showed that snowmelt differences among forest covers result from variations in energy transfers by solar and longwave radiation, convection, and condensation-evaporation. Many of the complex energy exchanges taking place in a hardwood forest snowpack are presented along with models to describe the process. NE (220).

368. Logging and burning old-growth Douglas-fir forests on an experimental watershed in the Pacific Northwest increased annual water yields by 18 inches or more. Treatments generally resulted in year-long increases in streamflow as well as substantial increases in minimum streamflow during dry summers. If sedimentation is kept at a minimum, such increases in streamflow patterns will likely benefit aquatic habitat. PNW (237).

b. Soil and other influences

369. Contour trenching of about 15 percent of the upper slopes of a high mountain watershed in Utah did not result in significant changes in annual water yield or spring snowmelt runoff. However, peak spring flow and peak summer flow were reduced after trenching. Contour trenching has been widely used in rehabilitation programs on numerous similar watersheds in the western United States, and these results suggest that water yield will not be altered by this practice. INT (217).

370. Water repellency in certain soils may impede infiltration just beneath the litter or in the upper soil horizons, depending on nature of the vegetation, composition of the micro-organic community, physical properties of the soil and fire history of the area. In addition to affecting water yield, water repellency plays a role in soil formation, distribution and growth of vegetation, and erosional processes. INT (221, 232).

371. In a mixed hardwood forest in Ohio, mcropores were found to consist of structural pores, open channels resulting from root decay, animal passageways, voids between roots and soil, and structural cracks. These macropores provide pathways or conduits for the rapid movement

of free water into and through the soil profile. In some instances, water movement was so rapid that only areas around the root channels were wetted. NE (210).

372. Ridge and coulee terrain in southwestern Wisconsin has little effect on point rainfall, but snowpack accumulation is affected by degree of slope and aspect. North slopes accumulate about 50 percent more snow, but aspect had little effect on soil water depletion. South slopes receive more insolation than north slopes although temperature differences are slight. Air drainage has a significant effect on night time air temperatures in coulee bottoms. NC (239).

373. Water collected on mountain logging roads when they are incised into the slope may be converted into rapid surface runoff, which may add to peak flow and threaten channel stability in mountain streams. Potential erosion through slumping of road banks and effects of such roads on the basin hydrograph should be considered in road planning. INT (215).

2. MANAGING WATERSHEDS

374. First-year results showed that snow fencing in southeastern Wyoming increased the water equivalent of the snowpack by about 70 percent on small watersheds, and demonstrate the potential for snow management in windswept areas. The snow fence system was designed to redistribute water on a drainage by concentrating snow in a relatively few large accumulations rather than many smaller drifts. RM (267).

375. Many of the forested municipal watersheds in the Northeast are located in or near densely populated areas and are receiving increased pressures for uses other than water yield. A recent survey showed that timber harvesting is allowed on 54 percent and some type of recreation on 59 percent of the watersheds. The survey indicated that management to increase water yield is successful on some watersheds, but is causing problems on others. NE (253).

376. Most upland runoff from overlying fields in the Driftless Area of Wisconsin was absorbed by forested slopes, with average lower station flow ranging from 56 to 94 percent of upland flow after large storms. The effectiveness of the forest zone in disposing of upland runoff appeared to be related to the ratio of forest to open-upland area. NC (265).

377. A method for revising streamflow forecasts based on snowpack depletion and precipitation in the Rocky Mountain West is presented utilizing a model which has enough flexibility to account for unusual hydrologic conditions. For one year, initial forecast errors were reduced by 10 percent. The method has promise for greater efficiency in reservoir operation. RM (258).

(For additional items relating to II F 2 see paragraphs 1, 364, and 369.)

3. WATERSHED REHABILITATION AND DAMAGE PREVENTION

378. Past land use, forest fires, road building, poor logging practices, and conversion of steep lands to grass have increased sediment production in the western United States by factors ranging from 1.24 to more than 4. Projected future use is expected to increase sediment production by a factor of 4, of which 80 percent would be associated with roads and 20 percent with logging. Quantitative measurements of soil characteristics, topography, land use conditions, and the meteorological impacts on these lands have provided a basis for predicting differences in expected sediment production from these sources. PNW (270).

379. In revegetating spoil banks in eastern Kentucky, growth of K-31 tall fescue was greatest where texture consisted of about equal parts of soil-sized material and particles 2 to 6.4 mm in diameter. This particle size distribution probably provides better physical soil properties, particularly aeration and moisture retention. Fescue grows best where soil particles are larger if spoils contain chemicals which limit plant growth. NE (282).

380. An intensive study of the effect of grazing on the hydrologic and biotic characteristics of small drainage basins on the Colorado Plateau has shown that ungrazed watersheds produced only 69 to 71 percent as much runoff as grazed ones. Sediment yield from ungrazed watersheds averaged about 66 percent of that on the grazed watersheds. Amount of bare soil and rock, ground-cover index, and amount of litter and moss changed significantly on grazed watersheds, but remained about the same on ungrazed ones. RM (278).

381. Dominant natural soil mass movement processes active on watersheds of the western United States are found to be encouraged or accelerated by destruction of natural mechanical support on slopes. Logging, road building, and fire play an important part in initiation and acceleration of these movements with road building providing the most damaging activity because of its effect on back slope cutting, slope loading, and drainage. Logging and fire may affect stability through destruction of natural support for the soils, removal of surface cover, and obstruction of drainage channels by debris. PNW (281).

(For additional items relating to II F 3 see paragraphs 1, 2, and 370.)

4. WATER QUALITY

382. Effects of logging and associated road construction on four northern California streams were not detrimental to anadromous fish production when adequate attention was given to stream protection and channel clearance. However, extensive use of bulldozers on steep slopes and in stream channels caused excessive sedimentation. Carrying capacities for juvenile salmonids were increased when high temperatures, low dissolved oxygen concentration, and adverse sedimentation did not accompany logging. PSW (286).

383. Cutting all trees and understory vegetation on small watersheds in the southern Appalachians resulted in increasing maximum summer stream temperatures by as much as 12 degrees F. above the normal 66 degrees F. which may exceed the optimum for trout habitat. Where streambank vegetation was uncut or had regrown, maximum summer temperatures remained unchanged. SE (291).

384. Timber harvest and slash burning on a watershed previously stocked with old-growth Douglas-fir resulted in nutrient losses 1.6 to 3.0 times greater than those on an undisturbed watershed. Nitrogen loss on the undisturbed area was about 0.16 pound per acre compared with 4.6 pounds per acre following the burning treatment. PNW (287).

385. Cleaning of gravel in three streams in southeast Alaska initially reduced bottom fauna populations in each stream, but within 1 year these populations apparently returned to pretreatment levels. The cleaning of gravel by removing excessive sediment is being done to improve spawning gravels for salmon production. PNW (290).

5. MEASURING ENVIRONMENTAL PARAMETERS

386. A portable, insulated evaporation pan was developed to give evaporation values that are highly correlated with those from standard U.S. Weather Bureau Class A pans, requires less water than conventional pans, and may serve as an all-wave radiometer for incident minus reflected light. This insulated pan may also be used at temperatures below 32 degrees F. INT (307).

387. A pump-manometer was designed to provide quick and accurate measurement of hydraulic conductivity in the field by means of either the auger-hole method or piezometer method. The device can be operated easily with a two-man crew, but with practice one man could perform the entire operation. The primary advantage of the manometer is that measurement of the rate of rise of water can begin as soon as the well is pumped dry without exchanging instruments. INT (302).

G. Bettering Silvicultural Systems

1. NATURAL REGENERATION

388. Knowledge of the seed crop characteristics of paper birch is essential for planning silvicultural measures to obtain successful natural regeneration of this species. A 3-year study in Maine revealed that about two-thirds of the total seed production is good seed, and that most of it is dispersed in October and November. Reasonably good seed crops occur about every other year, and adequate seed dispersal extends from about 30 feet into a forest opening in very poor seed years to more than 150 feet

in excellent seed years. This information will enable forest managers to schedule site preparation measures and to determine the appropriate width of clearcut strips. NE (968).

389. Knowledge of the chemical contents of fruits and seeds of trees can be very useful information in silviculture or wildlife habitat research. Analyses made on various seed collected in central Mississippi resulted in a list of values for crude fat, protein, total carbohydrates, phosphorus, calcium, and magnesium for 37 southern tree species. These analyses help appraise the place of the seed crops in the nutrient cycle as well as their food value for wildlife. SO (969).

390. Nurserymen have long been plagued by the very low percentage of full seed in yellow-poplar seedlots. A new method, developed in Mississippi, involving mechanical removal of wings and partitioning of the seeds into different specific gravity fractions to isolate full seeds, has resulted in upgrading of seed groups with an original soundness of 6 to 10 percent to 60 to 65 percent full seed. By using this method, nurserymen will be able to regulate bed density and thus seedling size for the first time. SO (970).

391. Accurate estimates of cone crops are needed to plan seedbed preparation and cone collection activities. In a 2-year longleaf pine study in south Alabama, it was found that binocular counts, made during early spring growth prior to needle development, multipled by a factor of 1.5, give a conservative estimate of total conelets on a seed tree. SO (971).

392. Phytotoxic substances can drastically alter the development of forest and range vegetation. In coastal North Carolina salicylic acid leached by rain from the crowns of large cherrybark oaks reduced survival and growth of both natural vegetation and planted seedlings. Such losses seriously affect the regeneration and silvicultural management of mixed-hardwood forests. SE (972).

393. Southern pines are often difficult to regenerate through natural seedfall because of extreme fluctuations in seed crops. In loblolly and shortleaf pines on loessial soil in southern Arkansas, summer logging produced 63 percent stocking, burning prior to logging yielded 69 percent stocking, disking prior to logging increased stocking to 89 percent and bulldozing after logging gave 99 percent stocking. Land managers can regulate site treatment to include both desired stocking and cost factors. SO (973).

394. Erratic seed crops in forest stands mean that stored seed must be available to sustain tree planting programs. Studies in northwestern Pennsylvania yielded a successful method of storing black cherry seed for at least 3 years. Seed is dried either to 4 to 6 percent moisture content and stored in a freezer at 0° to 6°F., or to 4 to 15 percent moisture and stored in a refrigerator at 38° to 41°F. Use of this method to store black cherry seed collected in good seed years for planting in poor seed years assures continuity in planting programs. NE (974).

395. Standard guidelines for natural regeneration of southern bottomland hardwood stands in the Coastal Plains are not available but observations and research indicate that the preferred system of regeneration would keep the overstory dense until a combination of harvesting and cultural treatments provided openings and favorable seedbeds. Then, regeneration would come from advanced reproduction, sprouts from the roots and stumps of cut trees, and seeds either lying dormant in the litter or moving in from larger trees, within 200 feet of the opening. Foresters can use this information to improve regeneration on thousands of acres of southern hardwood forests. SO (975).

396. Natural regeneration of oak stands requires establishment of an understory before the final harvest cut. Studies in Missouri with 10 percent, 30 percent, and full sunlight showed that first-year red oak seedlings failed to respond to an NPK fertilizer unless they had 30 percent or more of full sunlight. The light requirements of older seedlings and of seedling sprouts must also be explored to make this information more useful in developing regeneration practices. NC (976).

397. Periodicity or cyclic rhythms characterize cone production of western white pine. The yearly number of strobili, followed on 4 trees during an 18-year period in northern Idaho, indicated that periodicity in production of strobili by individual trees followed major cycles of 4 years. Within this cycle, individual trees tend to be in phase. This information should help forest managers and research geneticists schedule activities that depend on timing of cone crops. INT (977).

398. When a mature stand of upland oak timber is clearcut a high percentage of the oak advance reproduction stems are broken off, cut or damaged in some way. Observations in Ohio indicate that most of these damaged stems sprout and become the fastest growing and most desirable form of oak reproduction. Stems between 0.5 and 1.0 inches in diameter produced sprouts that attained favorable competitive positions in the new stand. This information permits appraisal of the adequacy of advance oak regeneration before final harvest cuts are made. NC (978).

399. Alternatives to clearcutting are needed in many timber types. Although western larch grows best under nearly full sunlight in the northern Rockies, seedlings rarely become established more than 150 feet from the edge of timber without well-prepared seedbeds. The seed tree and shelterwood methods (4 and 13 mature trees per acre, respectively) are more likely to promote evenly distributed natural regeneration than is clearcutting. A rating system is now available to help land managers evaluate the effects of various silvicultural practices in western larch on costs of logging, regenerating, and culturing as well as the effects on wildlife forage, livestock forage, water, and esthetics. INT (979).

400. Little is known about the seed production of young-growth ponderosa pine along the westside Sierra Nevada. Ninety-year-old seed trees ranging from 3 to 9 per acre produced 5,000 to 35,000 seeds per acre in years of moderate to heavy cone crop, which occurred at intervals of 1 to

3 years. In this type of timber, a minimum of 4 seed trees per acre should be selected from among the trees that show evidence of past cone production. PSW (980).

401. Measurements made on even-aged hardwood stands in West Virginia indicated that 7 years after a seed tree harvest, stems of many species were abundant and well distributed. Large reproduction, destined to make up the next crop, consisted mostly of species that had either sprouted vigorously, exhibited fast early growth, developed from root suckers, or reproduced under the old stand. These results indicate the great diversity of species and abundance of reproduction that can be expected after even-aged harvest cuts in Appalachian hardwoods. NE (981).

402. Natural regeneration of shortleaf pine is unreliable because of greatly fluctuating seed crops. Removal of all trees within 30 feet of seed trees more than doubled cone production and increased the number of sound seeds per cone by 9 percent during a 3-year period in the Ouachita Mountains of Arkansas. Forest managers should consider this release technique for satisfactory natural regeneration of shortleaf pine. SO (982).

403. The forests of interior Alaska are a complex mosaic of stands which are, to a significant degree, related to the fire history of the area. A comprehensive summary of information concerning seed production, seedbed requirements, and vegetative reproduction has been prepared for the 5 major forest tree species--white spruce, black spruce, paper birch, quaking aspen, and balsam poplar. These data provide a quantitative basis for evaluating the reforestation potential of newly burned areas in interior Alaska. PNW (983).

404. A late May frost in interior Alaska killed or damaged developing conelets of white spruce, resulting in a reduction of more than 50 percent in cones and seeds in some stands. This is the first report of such damage during 12 years of cone and seed crop observations in this region; therefore, it probably has only minor influence on overall seed production. But because of the infrequent seed crops, frost damage could have an unfavorable impact on seed collection or other activities that depend on large amounts of seed from limited-area or special purpose stands. PNW (984).

2. SILVICULTURAL METHODS

405. Forest managers in the central Rocky Mountains are faced with the problem of changing established timber harvesting practices to meet the needs of all forest uses. Interim guidelines are now available to aid the manager in developing alternatives to clearcutting old-growth spruce-fir forests. Alternative partial cutting practices provide for maintenance of forest cover in recreation areas, travel influence zones, and scenic view areas; other patterns of cutting give options for increasing water

yield, improving wildlife habitat, or integrating timber production with other key uses. RM (985, 986).

406. A synthesis of past research shows that advance oak reproduction is the key to forming the new oak stand. However, the size and vigor of the advance stems is as important as the number. If oak stands approaching maturity do not have enough advance reproduction, harvest cutting must be delayed and overstory densities regulated to favor the establishment and development of new oaks in the understory. These results provide a basis for an understanding of oak ecology that is essential to the planning for uniform long-term flow of goods and services from oak forests. NC (987).

407. Western hemlock and Sitka spruce are generally harvested by clearcutting, but there are situations where some other method would be preferable for esthetic or other reasons. A study in southeastern Alaska showed that crop trees left in a 96-year-old stand after partial cutting were able to increase or maintain the same rate of diameter growth as before thinning, whereas diameter growth of unthinned trees declined. Partially cut plots became well stocked with conifer regeneration but opening the stands stimulated epicormic sprouting. The results show that thinning in such stands is feasible and provides an option to clearcutting for use under special management objectives. PNW (988).

408. A carefully designed sanitation-salvage-esthetic cutting in a roadside zone in north central California demonstrated that this type of culture in Sierra mixed conifers can enhance their esthetic value as well as their potential for wood products. Because of the "special care" procedures followed, combined logging and slash disposal cost was $30 a thousand board feet, about twice that of a single tree selection cut in the general forest zone. PSW (989).

409. To reproduce upland central hardwoods most successfully, the harvesting method chosen must create conditions that satisfy the ecological requirements of the species wanted in the new stand. A summary of studies of central hardwoods after harvest cuts, that ranged from single-tree selection to complete clearcutting, shows that heavier cutting favors intolerant species and faster growth of all species. Yellow-poplar reproduction is primarily seedings, but oaks, hickory, maples, blackgum, sassafras, and dogwood come mostly from advance reproduction and sprouts. These results provide land managers with realistic evaluations of the silvicultural alternatives for the regeneration of upland hardwood forests. NC (990).

410. Dense stands of young ponderosa pine seriously hamper forest management in Arizona and New Mexico. Forty 4-year-old stands, averaging 5,844 stems per acre were thinned to 6 growing stock levels (GSL) representing future basal areas of 30 to 150 square feet per acre. Net dbh periodic annual increment (PAI) was 4.6 times greater at GSL-30 and 2.2 times greater at GSL-150 during the first 5 years after thinning than

the prethinning rate. The PAI of the 100 largest trees per acre showed improvement in diameter, basal area, and volume with increasing growing space. RM (991).

411. The recent controversy over site preparation practices and planting investments on National Forest land in Montana has resulted in certain proposals for natural regeneration of ponderosa pine in this area. A summary of ponderosa pine regeneration and problems in the Northern Rocky Mountain region shows that: 1) natural regeneration usually is slow and frequently uncertain; 2) competition from understory vegetation is intense and usually requires site preparation after cutting for success of natural or artificial regeneration; and 3) planting nursery stock on well-prepared sites can be relied upon to obtain adequate restocking within acceptable time limits. INT (992).

3. ECOLOGICAL RELATIONSHIPS

412. Lack of soil moisture is a limiting factor for successful regeneration in the Southwest. A recent field study of soil moisture availability during the growing season in a clearcut mixed conifer stand in Arizona indicated that the soil moisture deficit approached or exceeded the permanent wilting point only under grass on level and southerly exposures. Adequate moisture was available under burned and scalped surfaces for survival of established seedlings and planted trees throughout the growing season on all exposures. These findings will help forest managers diagnose regeneration problems and prescribe successful treatments in mixed conifer stands where restocking has been difficult. RM (993).

413. Conifer seedlings have invaded large portions of subalpine meadows in the Washington and Oregon Cascades, including many sites where the meadows are key recreational attractions. Fire, grazing, and forest edge effect are possible contributing factors, but the most probable cause is a change in climate beginning in the late nineteenth century and extending into the 1940's. Land managers who wish to maintain the meadow landscapes should be able to control this encroachment by cutting the seedlings. Successional pressures are not great, and a recurrence of favorable environmental factors will probably be necessary before substantial reinvasion of conifer seedlings occurs. PNW (994).

414. Severe soil compaction can result from logging under wet conditions and with heavy equipment on medium- and fine-textured soils on the Atlantic Coastal Plain. Studies in southeastern Virginia indicate that the average time required for severely disturbed soils to recover naturally to normal surface densities is approximately 18 years. Because pine establishment and early growth are greatly reduced on severely compacted soils, forest managers should seek ways to avoid, minimize, or correct compaction damage. SE (995).

415. Mathematical models attempt to accurately describe or predict conditions in or performance of real-world systems. Few models of this

type are available for entire ecosystems. An experiment in modeling southern Rocky Mountain forest ecosystems has yielded a prototype model that integrates selected climatic, edaphic, and topographic factors and relates them to site index of quaking aspen. Although only parts of the model are useful for ecological research in the southern Rocky Mountains, the concepts and methods developed are useful for ecological research in mountain regions generally. RM (996).

416. Delineation of forest stands into environmental classes, and development of land management techniques tailored to fit each class, will permit improved forest management. A classification system using elevation, potential solar radiation, soil type, and plant indicator species (indicators of temperature and moisture conditions) has been developed for forest environments in the South Umpqua Basin in Oregon. Although this system has direct application only to the mature mixed conifer forests in the Basin, the classification technique can be adapted to develop similar classifications for other areas. PNW (997).

417. Shallow water tables underlie some of the most important recreational areas in the Pacific Northwest--the edges of streams, lakes, and reservoirs. A study of the occurrence and radial growth of four tree species on the Olympic Peninsula, Washington, showed that native red alder and western redcedar grew well where stagnant water was less than 15 cm. from the soil surface. Alder and Sitka spruce also grew well where flowing water occurred near the surface, but western hemlock seemed intolerant of all water tables less than 15 cm. deep. If these tolerances are recognized in management decisions, forests of healthy trees can be maintained on the shallow water table areas. PNW (998).

418. Bristlecone pine is one of the oldest living organisms known to man. Studies of these ancient trees in the San Francisco Peaks of Arizona (elev. 9,600 feet) reveal that vegetative buds start swelling early in June, buds burst and active elongation begins in mid June, and male flowers mature and release pollen by late July. This information will aid those who must time their visits to stands of this species with the occurrence of a particular phenological event. RM (999, 1000).

419. The distribution and rates of accumulation of biomass and nitrogen have been determined for 5-, 15-, and 20-year-old alder ecosystems developing on the Tana River flood plain in central Alaska. The mean annual rates of both biomass increment and nitrogen build-up are rapid during the first 5 years, but decrease with increasing ecosystem age. The study contributes to our understanding of ecosystem development, from sandbar establishment through 20-year-old alder stands, within the broader framework of forest succession in interior Alaska. PNW (1001).

(For an additional item relating to II G 3 see paragraph 383.)

H. Remote Sensing Methods

420. Project Fire Scan has been developing infrared fire detection systems since 1962 to overcome limitations of visual detection methods caused by darkness, atmospheric contamination, and the difficulty of finding glowing fires which produce little smoke in early stages. Development procedures required the construction and field testing of an electronic scanning system designed to reliably identify fire targets and determine detection probabilities over a range of forest canopy conditions (open to closed). The present bispectral, or "two-color," system used in combination with well-planned visual detection will result in a more efficient system than visual methods alone. INT (387, 397).

421. An improved bispectral infrared forest fire detection system was field tested in an 8,000-square-mile, Montana-Idaho study area during the 1970 fire season. The new equipment identifies and marks fires as small as 1-ft.^{2} in the forested mountain environment. Approximately half of the fires in the study area were scanned by the airborne equipment and over 50 percent of these were detected. INT (388, 391).

422. Development and testing of a bispectral airborne forest fire detection system indicates a capability of detecting 1-ft.^{2} of burning material (600^{o}C.) against backgrounds ranging from 0^{o} to 50^{o}C. from 15,000 feet. The bispectral infrared system provides a 10:1 improvement in target-to-background signal ratios over the monospectral system. INT (389, 394).

423. A small, inexpensive infrared scanner, designed for light aircraft and helicopters, helps locate small fires detected by the bispectral infrared system. These "fire spotters" are capable of detecting 1-ft.^{2}, 600^{o}C. targets at altitudes up to 2000 feet during daytime conditions. The small fire spotters picked up 26 fires in 1970 which would not have been found until later by visual methods. INT (389, 390).

424. Decision rules for controlling an infrared forest fire detection system are derived from simulated detection patrols. These studies provide procedures for determining the most effective operating rules for given budgets. Results are compared to the existing detection system in the Montana-Idaho study area. INT (392, 396).

425. A computer-based model of a small smouldering or creeping forest fire simulates burned and burning areas of a fire at any time after ignition. INT (393).

426. Early tests indicate that a prototype infrared system for observing fire through smoke has advantages and a sensitivity that surpass conventional systems. A comparatively recent development in electronic technology holds promise for providing a practical means for locating and following the progress of forest fires. PSW (395).

427. Small-camera aerial photography determines the volume within a pile of organic material through computer analysis of parallax readings. INT (386).

I. Weather Modification and Weather Effects

428. Modeling of Rocky Mountain lightning storms is enhanced by the modification and testing of two types of mathematical cloud models, the so-called steady-state and time-dependent models. Preliminary results comparing features of real clouds with those of computer-simulated clouds are encouraging. The development of numerical cloud models may produce a new, stronger means of studying the complex physical and electrical interactions of lightning storms. INT (400).

429. Information has been summarized on the worldwide occurrence of lightning, lightning-caused wildland fires, and the ecological ramifications of lightning effects as precursors to forest insects, disease, wind, and fire. INT (405).

430. The large-scale cross section and terrain surface analyses of potential temperature are presented as aids for studying mesoscale and finer weather variations. These analyses, based on a parameter (temperature) that is rarely treated in detail in mountainous terrain, present conditions directly related to airflow near and above the terrain surface. PSW (399).

431. Logging slash outside of smoke sensitive areas can be disposed of by open burning with a minimum contribution to air pollution by controlling time, location, and quantity of fuel. Minimizing air pollution from slash burning requires the effective use of weather forecasts for matching amount of burning to dispersion potential. PSW (398).

432. Causes and methods of predicting strong low-level winds were investigated using data obtained during two wildfires. Results showed that strong winds on these fires were probably a product of several mechanisms in combination. PSW (403).

433. Large losses result mostly from the behavior of fires influenced by such weather systems as fronts, the warm sector of cyclone systems, and sea breeze fronts. Effects of these systems may prevail for only a few hours, may be fairly local, and tend to be under forecasted. SE (407).

434. Calculated values of precipitation effectiveness index and temperature efficiency index for 48 weather observation stations on the Alaska mainland are used to delineate areas that have different climatic subclassifications during the wildfire season of April-September. The paper outlines procedures, provides maps showing step-by-step analysis and areal boundaries, and suggests possible uses of the information. PNW (406).

435. A simple probability model is used to relate a characteristic space scale measure to point frequencies. The importance of the relationship between scale and predictability suggests the need to define rational scale measures for various weather phenomena. WO (402).

III. IMPROVING TIMBER PRODUCTIVITY AND EXTENDING SUPPLIES

A. Intensive Culture Methods

1. SITE EVALUATION AND SOIL IMPROVEMENT

436. The presence and persistence of epicormic branches can seriously degrade hardwood log quality. In uncut stands in West Virginia large numbers of epicormic branches that appeared during the spring died during the growing season on dominant and codominant red oak and yellow-poplar. Nitrogen, phosphorus, and potassium fertilizers did not stimulate the formation of epicormic branches but nitrogen did increase the vigor and growth of established epicormic branches on the upper sections of the bole. These findings indicate nutrients designed to promote volume growth may be applied without fear of decreased quality through increased numbers of epicormic branches. NE (1002).

437. There is only limited information available about the fertility of virgin forest soils in West Virginia. Research in five locally important forest soils supporting stands containing a high proportion of red, chestnut, or scarlet oak indicated that except for nitrogen, for which there were not clearly defined differences between soils, levels of nutrients are generally associated with the type of rocks from which the soils were formed. Characterizing soil nutrient levels by identifying the soils series and its underlying geologic formation will be useful in oak management and in the design of field experiments in silviculture. NE (1003).

438. Recently devised methods of developing site index curves were used to investigate patterns of height growth in eastern white pine and the impact of these patterns on the estimation of site index. Highly significant differences in the growth curve and its parameters were associated with the quality of the site. Allowing for the changes in growth patterns with the level of site index reduced the average difference between observed and estimated site index from 4.4 feet to 1.0 feet. SE (1004, 1005).

439. Site indices for natural stands of slash pine are determined from reference curves based on an index age of 50 years, whereas present curves for plantations are based on an index of 25 years. Foresters and tax assessors frequently need to equate sites for the two types of stands, but precise conversion values have not been available. Analysis of the most recent yield studies showed that a conversion based on yield is more accurate than one based on height. This led to the development of precise equivalent values at age 25 for 25-year and 50-year sites on the basis of comparisons of cubic yield for planted and natural stands. SE (1006).

440. Broadly speaking, we know that soil physical conditions, available water during the growing season, soil aeration, and nutrient availability regulate forest productivity. Many of the factors that affect these valuables

cannot be measured, neither can they be ignored, so their effects must be estimated. A summary of available research information has been prepared that described various techniques, methods and systems of soils management that may be applied in growing bottomland hardwoods in the lower South. SO (1007).

441. For the Central States, the only site index curves for upland oaks are harmonized curves presumed to be applicable to all oak species. Studies based on stem analysis measurements of black, white, scarlet, and chestnut oaks revealed that these four species have different patterns of height growth and polymorphic height growth patterns for different levels of site quality. The refined site index curves developed for each species provide the practicing forester with an improved tool for intensive culture of the upland oaks. NC (1008).

442. A forest manager often has difficulty deciding which tree species to favor on a given type of land. Comparative studies in some other regions have shown considerable differences in the site index of the same land for different tree species. However, site index comparisons for several hardwood and conifer species in northern Minnesota indicated relatively consistent site-index differences between species at all site qualities. Thus the forest manager has more latitude in that area for adjusting forest composition to meet multiple-use objectives. NC (1009).

443. Intensive management is necessary for rapid growth and development of high-value hardwoods. A recent pot study in Iowa showed that fertilization of black walnut with N, P, and K increased growth only under moist conditions and that nitrogen was the primary element responsible. It is important that adequate moisture be available before fertilizing this species because high rates of fertilization under dry conditions may actually retard tree growth. NC (1010).

444. Height growth patterns for upland oaks are highly variable and standard site index curves often do not accurately describe growth patterns for a given geographical area. Site index curves for white oak and for northern red and black oak growing in the Boston Mountains of northern Arkansas more closely reflect growth patterns than do Schnur's harmonized site curves developed for the entire commercial range of oak. SO (1011).

445. The potential for pine production in much of the Boston Mountains of Arkansas is unknown. Regression equations using elevation, slope, aspect, and organic matter of the surface soil give a practical means of estimating the site index of shortleaf pine for the major soils of this retion. SO (1012).

446. Yellow birch develops a very shallow root system in New England forest soils which no doubt restricts tree growth and development. Studies in New Hampshire showed that subsoils deficient in calcium and high in aluminum restricted root and top growth even though the upper soil layers contained adequate nutrients. These results indicate that subsoils may

require limestone and fertilizer additions to develop the vigorous and healthy birch trees needed to maintain adequate wood supplies for local industries. The feasibility of deep fertilization and liming of forest soils remains to be determined. NE (1013).

447. Burning influences the nitrogen (N) fixing capacity of soils because it changes the moisture and temperature regimes. Annual burning of loblolly pine stands for 10 years in the lower Coastal Plain of South Carolina resulted in an average soil N fixation of 1 kg/ha/year, which was ten times the rate on nonburned areas. Many of the samples had much higher rates, and half of the samples fixed little or no N regardless of burning treatment. If the properties of soil which have high fixation rates can be enumerated and the rate of fixation increased by burning or other simple, inexpensive procedures, the need for extensive fertilization may be greatly reduced. SE (1014).

448. The concentration of yellow-poplar roots in the surface horizon in some Hartsells soil profiles in Tennessee suggests that root penetration may be limited by subsoil properties. Research results based on soil analysis, seedling size, and the appearance and distribution of roots within the soil indicate calcium deficiency, aluminum toxicity, or a combination of the two as the limiting factors. This information will help to guide the course of further research on yellow-poplar nutrition and site adaptation. SO (1015).

449. Populations of microfauna in the forest floor (F-layer) depend to a great extent on moisture conditions. A laboratory experiment showed that animals move from a drying forest floor to the underlying mineral soil. Results demonstrate that the surface soil should be sampled along with the decomposing organic matter if the microfauna of a forest are to be measured accurately. SE (1016).

450. The soil mesofauna play an important part in the decomposition process by breaking organic tissue down into particles small enough to be decayed by fungi and bacteria. Fundamental research on the effects of prescribed burning in South Carolina revealed that there was a significant reduction in the soil mesofauna immediately after an annual summer burn. After periodic burning, the mesofaunal population returned to the levels found on unburned plots in less than 43 months. This is the first published report concerning the effect on soil mesofauna of prescribed burning under defined conditions and frequency. SE (1017).

451. California black oak is a potentially valuable species of wide distribution in California and southern Oregon. Site index curves related to aspect and to the site index of a close associate, ponderosa pine, have been developed. These curves should be useful in estimating the growth potential of California black oak in even-aged unmanaged stands in northern California. PSW (1018).

452. A review of recent research on effects of prescribed fire on soil physical properties indicates that if all of the surface organic layer is

consumed by intense fire, drastic changes in macropore space, infiltration, and aeration followed by surface runoff and erosion can be expected in hilly terrain. If burning is used as recommended in southern pines management (e.g., causing only partial destruction of the forest floor), the danger of runoff and erosion is not nearly as great as can be expected from mechanical methods of site preparation or wildfires which would replace prescribed burning. SE (1019).

453. The extensive pine regeneration programs underway in the Southeast require greatly increased production of genetically superior planting stock. Results of 5 years of intensive culture in a slash pine clonal seed orchard in northeast Florida indicate that nitrogen fertilization plus irrigation during the spring increases the number of seed per cone. But irrigation in late summer may suppress both male and female flower development. Clonal lines differ greatly in flowering in response to fertilization and irrigation. This information will help managers to maximize production from slash pine seed orchards. SE (1020).

454. How burning affects soil nutrient levels is a controversial subject. Results of 20 years of annual or periodic prescribed burning in the South Carolina Coastal Plain show that losses of organic matter and nutrients from the forest floor are offset or exceeded by increases of both in the mineral soil. Results indicate that burning neither enriches nor depletes southern soils. SE (1021).

(For an additional item relating to III A 1 see paragraph 370.)

2. ARTIFICIAL REGENERATION

455. Flotation in a liquid of suitable specific gravity is an ideal means of separating full and empty seeds of many coniferous species. Flotation in ethanol caused the viability of spruce pine and slash pine to decline in storage. Drying for 4 hours after soak alleviated this effect for slash pine but even extended drying was only partially effective for spruce pine. It is recommended that flotation of spruce pine seeds be delayed until just prior to use. SO (1022).

456. Several published reports have indicated that planting cottonwood cuttings in auger holes is superior to planting in a planting rod hole. Inserting a 20-inch cutting into a planting rod hole was found to be as effective for establishment and growth of cottonwood plantations as the auger hole method. Results should benefit forest managers in the Mississippi Delta since they indicate no reason to use the more expensive techniques for planting cottonwood. SO (1023).

457. Costs of controlling nursery pests such as diseases, insects, and weeds are often major expenditures in the production of planting stock. Soil fumigation of 2 northern Rocky Mountain nurseries in the late summer with medium to high rates of methyl bromide-based fumigants (170 to 340 lb./acre) has controlled pests, increased seedling survival, and

stimulated the growth of Douglas-fir, western white pine, Engelmann spruce, and ponderosa pine. Seedling production time has been reduced by up to one year at a cost saving of from $3 to $4 per thousand seedlings. INT (1024).

458. Both prairie crayfish and short-tailed crickets are predators of pine seed and newly germinated seedlings. Recent studies in central Louisiana have shown that losses are normally small and recommended sowing rates are high enough to offset this predation. Results of these studies have eliminated two suspects as serious predators of direct-seeded pines. SO (1025, 1026).

459. Mechanical site preparation is expensive and should not be used for regeneration unless it can be justified economically. After 14 years, direct-seeded slash pine on disked and furrowed plots in central Louisiana were 2 to 3 feet taller and 0.3 to 0.4 inch greater in diameter than those established on a grass rough. Disking prior to direct seeding slash pine is the preferred site treatment on open grassy areas in the West Gulf Coastal Plain because it increases growth over no preparation and reduces the risk of drought loss inherent in furrowing. SO (1027).

460. Many areas of the South cannot be quickly regenerated by planting because of rising costs and labor shortage or by natural regeneration because of the demand for prompt restocking. Direct seeding has proven to be an acceptable method for obtaining regeneration. A new USDA Handbook brings together detailed management guides for direct seeding longleaf, loblolly, slash, shortleaf, Virginia, and white pines under a broad array of conditions within the South. This technique gives a land manager substantially more options and in many cases greater economy in maintaining full productivity of his forests. SO (1028, 1037).

461. Is the advance reproduction that survives after mechanical tree harvesting in northeastern spruce-fir forests adequate to regenerate the stand? In Maine, after winter logging with a Beloit Tree-Harvester and a rubber-tired skidder, the stocking of surviving seedlings on most of the logged areas remained adequate for the two years of record. Survival was greater off skidroads than on them, and heavy slash accumulations contributed most to both spruce-fir and maple-birch seedling mortality. NE (1029).

462. Because Puerto Rico has no native pines, successful introduction of exotic species would help to broaden the reforestation program. Survival and height growth of nineteen conifer and two broadleaf species in single tree plots indicate that Honduras pine (Pinus caribaea var. hondurensis) grow best on a variety of sites, although several other pines deserve further trial. The trees are still too young to assess wood quality, but the single tree plot techniques has permitted repid economical testing of a large number of species over a wide range of sites. ITF (1030).

463. Frost heaving causes serious losses to direct-seeded white pines in New England. Forty percent artificial shading during the dormant

season reduced mortality from frost heaving to about one-third of that under full sunlight by reducing incoming radiation during the day and conserving soil heat at night. Direct seeding under a natural vegetation overstory reduces frost heaving and has the additional advantage of maintaining a forest cover during the regeneration period. NE (1031).

464. Steep unstable slopes severely limit the number of regeneration techniques that can be used successfully in the Idaho Batholith. Hand scalping plus a pre-emergence herbicide (simazine) treatment applied in the fall was the most promising of 7 site preparation treatments in terms of cost and effectiveness for regeneration of ponderosa pine. Results verify that site preparation and vegetative control should be used to improve survival and growth of planted ponderosa pine seedlings in this extensive problem area. INT (1032).

465. Pure or nearly pure oak stands throughout the Upper Mississippi Valley may have a scarcity of desirable reproduction after cutting. Trials in southern Wisconsin indicate that the relatively fast growth, high survival, and adaptability of white ash transplants make them the safest selection for interplantings on oak clearcuts. Transplants should be large, with about 2-foot tops, and planting should be accompanied by control of stump sprouting. These findings give the forest manager a reasonable alternative to regeneration of oak in an area where this is very difficult. NC (1033).

466. How long weed control should be continued to maintain good survival of newly planted black walnut is a problem. Research in Iowa and Indiana indicates that at least 2 years of complete weed control is needed for rapid growth and when weeds are controlled for the first 2 or 3 years, trees can be expected to grow rapidly for at least 2 or 3 additional years after weed control is discontinued. Application of these findings is important to the success of walnut plantings. NC (1034).

467. Although there are some 30,000 acres of cottonwood plantations in the lower Mississippi Valley, the effect of initial tree spacing on growth is unknown. Research near Fitler, Mississippi, provided stand and growth information at 4 spacings (4X9, 8X9, 12X12, and 16X18 feet). With present utilization standards, the 12X12 spacing appeared to be the best. It produced 18 cords of merchantable wood in 7 years and an average annual diameter growth of one inch. SO (1035).

468. Natural regeneration of lodgepole pine is sometimes limited by intensive competition from understory vegetation and a dearth of serotinous cones that usually supply adequate amounts of seed. On such areas of regeneration other methods are needed. Hand-prepared, 12-inch-square, scalped seed spots yielded 72 percent stocking of lodgepole pine on slopes less than 45 percent in the Abies/Vaccinium habitat type in Wyoming. Results demonstrate that it is feasible to direct seed lodgepole pine on high elevation (7,900 ft.) sites in Wyoming. INT (1036).

469. It is often difficult for a small landowner to understand how he can make a continuous profit from his woodland. An understocked 30-acre loblolly pine woodlot in Georgia was managed for 20 years by cutting and replanting one acre each year. During the 20-year period of management, basal area on the average merchantable acre increased from 28 to 88 square feet, while an average annual harvest of 22 cords was obtained per acre harvested. SE (1038).

470. The Southeastern Area for State and Private Forestry will soon distribute limited numbers of cuttings from clones of eastern cottonwood selected for pulpwood and timber production in the lower Mississippi River Valley. To produce sufficient numbers of cuttings for field planting, nurserymen will have to propagate vegetatively the cuttings they receive. Mist propagation has proven reliable for expanding cottonwood clones in experimental and production nurseries in the mid-South. The procedure is relatively inexpensive and the equipment necessary need not be elaborate. SO (1039).

471. Today a hardwood plantation is a rare sight in the southern Appalachians but a recent summary of research results shows that such valuable species as yellow-poplar, black cherry, black walnut, and some oaks can be planted in the region with considerable success. The potential of assured regeneration of the fine hardwoods can do much to promote intensive forest management for the benefit of the rural economy. SO (1040, 1041).

472. Airlayering is a useful technique for the establishment of genetically uniform plants for research and the multiplication of selected germ plasm, but little information is available on the long-term growth and development of the resulting trees. Studies in northeastern Florida revealed that 12-year-old airlayers of slash pine rooted nearly as well as trees grown from seed, and that they had equal root surface areas but no tap root. Stem growth was the same, indicating that trees grown from airlayers perform as well as seedling stock. SE (1042).

473. The high number of direct seeding failures in northwestern California indicates the need for a better understanding of Douglas-fir seeding requirements. Research on the Klamath and Six Rivers National Forests showed that seed should be sown in November or December and better seedling establishment will occur on fine-textured red soils than on coarser grey-brown soils. PSW (1043).

474. Genetic crosses between American and European poplars (Populus spp.) produced many promising hybrids. As part of a regionwide test of these hybrids, 50 clones were outplanted on well-drained, alluvial sites in West Virginia. Over a 20-year period, the five best clones averaged between 0.4 and 0.5 inch annual diameter growth and 3.5 to 4.0 feet annual height growth. Since these hybrids are easily propagated by cuttings and will grow rapidly on bottomland sites, they may be useful in stabilizing streambanks and reducing siltation in streams. NE (1044).

475. In Hawaii, selection of tree species for reforestation may be a serious problem because of wide differences in climate and soils. Results of adaptability tests of several tree species indicate that Nepal alder, blackwood Acacia, Java podocarpus, and native koa have desirable characteristics for reforestation. Planting trees on marginal and abandoned pasture and cultivated lands in Hawaii could increase their economic value through production of timber, improved watershed conditions, and scenery. PSW (1045).

3. STAND IMPROVEMENT

476. There is an urgent need for herbicides which are as effective as foliar sprays of 2, 4, 5-T but less hazardous to the environment. Formulations of dicamba and picloram, alone or in mixture with 2, 4, 5-T, effectively controlled stands of mixed hardwoods in central Louisiana when applied at the rate of 1 to 2 pounds per acre. However, loblolly pine was more susceptible to these sprays, restricting their use for pine release. SO (1046).

477. There has been no way to determine success of foliar spraying for brush removal earlier than one year after treatment. Ten years of experimentation with more than 50 herbicidal formulations in central Louisiana showed that unless a herbicide initially defoliated at least three-fourths of a hardwood tree crown, there was a 95 percent chance that later topkill would be unsatisfactory. SO (1047).

478. Selective thinning of pine plantations often cannot be justified because of rising costs of marking and harvesting individual trees. A 15-year test with loblolly pine in southern Arkansas showed that a combination of row and selective thinning permitted mechanical harvesting plus the silvicultural advantages of selective thinning without sacrificing yield. SO (1048).

479. Salmonberry and thimbleberry are troublesome brush species that quickly occupy forest land after logging or wildfires in Coastal Oregon and Washington. Herbicides are needed that will give long-term control without damaging young trees. Low volatile esters of 2, 4, 5,-T appear to be more effective than amitrole-T and less expensive than mixtures of picloram and phenoxy herbicide amines when used as midsummer foliage sprays. PNW (1049).

480. Many hardwood species are resistant to herbicides currently in use. Researchers in Louisiana observed additive effects in absorption and lateral and downward movement of a combination of 2, 4, 5-T ester and dicamba applied to sweetgum, water oak, red maple, and loblolly pine. This mixture makes an effective spray which contains lesser amounts of any one phytotoxin than is possible when only one herbicide is used, thereby reducing the concentration of a potentially hazardous chemical in the ecosystem. SO (1050).

481. Douglas-fir does not occur naturally in Alaska. The results of several introductions of this species in southeastern Alaska during the last 40 years show that it is capable of germinating, becoming established, making excellent growth, and producing viable seed more than 200 miles north of its natural range on the coast. This suggests that Douglas-fir may have future silvicultural value in this area. PNW (1051).

482. High-quality southern hardwoods grow rapidly on river and stream bottoms and other moist, rich sites in the Coastal Plains, true swamps, and loess bluffs, and are extremely diverse in species, wood quality, and uses. Research findings on protection, thinning, planting, natural regeneration, harvesting systems, utilization standards, and other factors entering into management decisions have been synthesized for the forest landowner interested in increased returns from management. SO (1052).

483. An effective soil herbicide could be very helpful in controlling cull hardwoods. Of three soil herbicides (bromacil, picloram, fenuron) applied to clayey soils of central Louisiana, only bromacil satisfactorily killed blackjack and post oaks. Best kill was obtained by using 2 grams per inch of trunk diameter spread uniformly around the base of each tree during the period March to June. SO (1053).

484. Undiluted 2, 4-D amine is the standard chemical used to kill weed trees; however, it is not fully effective on a few resistant species. Mixing Tordon with 2, 4-D is more effective than 2, 4-D in winter. It also permits year-around control of blackjack oak, mockernut hickory, and sweetgum, species resistant to 2, 4-D amine, and saves labor through wider spacings between injections. SO (1054).

485. Because of the lack of information on the behavior of cull trees, the usual procedure in timber stand improvement work has been to treat every living cull tree. Research in West Virginia showed that 57 percent of poor-vigor culls and 27 percent of the overtopped culls died within 7 1/2 years after a partial cutting. The remaining trees in these two classes did not require treatment. Treating only culls that have an adverse effect on the stand can result in appreciable savings to owners practicing intensive forestry. NE (1055).

486. Precommercial release of crop trees can improve species composition, stand quality, and tree growth. Practical guidelines developed for even-aged Appalachian hardwood stands indicate that crop-tree releases (1) should be postponed until the stand is 9 to 12 years old; (2) should be done with hand tools by a carefully trained woodsman; and (3) that selection among crop-tree species that need light should be restricted to dominant and codominant stems. Earlier treatment was partially ineffective because of the rapid regrowth of trees and vines in younger stands. NE (1056).

487. When Appalachian hardwoods are clearcut down to a 5-inch diameter limit, a number of living unwanted stems less than 5 inches are

left standing. A comparison of basal spraying and power saw felling for eliminating these stems indicated that felling with the power saw was 30 percent cheaper, 100 percent effective in removing the offending stems, and left the area much more acceptable esthetically. NE (1057).

(For an additional item relating to III A3 see paragraph 5.)

4. ANIMAL DAMAGE

488. Pocket gophers occupy many acres of wild land in the western States, and are known to damage and kill several conifer species. A study in south-central Oregon revealed that losses of planted ponderosa, Jeffrey, and lodgepole pines were nearly identical, that damage occurred predominantly during the winter, and that two-thirds of the experimental plantation was destroyed within 3 years. Thus it does not appear possible to minimize damage by planting one of these species in preference to the others. Also, control measures to reduce gopher numbers should be scheduled just before winter, and plantations in area infested with these animals are probably doomed unless effective protective measures are undertaken. PNW (1058).

489. Safer chemicals are being sought to replace endrin (a chlorinated hydrocarbon) as a coating to protect conifer seeds from seed-eating rodents. In Washington, bioassays using deer mice showed that R-55 (a thiocarbamate derivative) was ineffective as a protective coating, but mestranol (an antifertility chemical) reduced Douglas-fir seed consumption to levels comparable with endrin. Continued research on mestranol and similar compounds is called for, although even if proven environmentally acceptable and effective in the field, the current high cost of mestranol may make its use uneconomic. PNW (1059).

490. Predation may be extensive if repellent-treated seed are sown too early in the season. A recent study in central Louisiana showed that loblolly pine and slash pine seeds exposed to 45 days of weathering may lose up to 70 percent of the endrin protective coating. Direct seeding should be scheduled to minimize the time between sowing and germination, so as to insure that effective amounts of the repellent are retained on the seed. SO (1060).

491. Although direct seeding of Douglas-fir in the Pacific Northwest can be done successfully by coating the seeds with endrin to protect them from seed-eating rodents, many operational seedings still fail. An experiment in Washington revealed that some seeding failures could be due to insufficient endrin on the seed because of inadequate seed treatment, and to endrin losses during aerial dissemination and weathering. In addition, the study suggests means for improving treatment, and points to the importance of chemical analysis in evaluating safer chemicals to replace endrin. PNW (1061).

492. Ponderosa pine seed development and survival studies in northwestern Montana showed that small forest animals utilize 24 out of 25 seeds that reach maturity. Red squirrels use about two-thirds of the seeds while deer mice, chipmunks, and birds consume the remaining one-third. Results show the dependence of animal populations on conifer seed production and the severe potential impact of some animals on forest regeneration. INT (1062).

493. Following harvest cutting, natural regeneration of ponderosa pine in western Montana frequently is slow and uncertain. The major factors causing this poor regeneration are cone abortion, squirrel cutting of cones, and rodent destruction of seed on the ground. A landowner can reasonably expect to control: 1) most squirrel depredations by banding seed trees, 2) 50 percent of the seed losses on the ground by controlling seed eating rodents, and 3) 50 percent of the first-year seedling losses by thorough site preparation. INT (1063, 1064).

5. GROWTH REQUIREMENTS

494. Upland species usually grow slowly when planted on wet sites. Root respiration (an important growth process) of upland species, loblolly pine and yellow-poplar, was nearly twice as high as that for lowland species, weeping willow and river birch. Comprehensive information of this type contributes to our understanding of why and how species adapt to particular sites. SO (1065).

495. Protracted flooding frequently reduces growth of southern pine seedlings. Flooding for 21 weeks during the dormant and early growing season depressed loblolly pine seedling growth 15 to 26 percent whereas flooding for 7 weeks during the dormant season caused no loss in growth. Owners of forest lands subject to frequent flooding which does not inundate terminal buds can anticipate marked loss in growth if continuous flooding occurs during the growing season but little or no loss from brief dormant-season flooding. SO (1066).

496. If sugar maple seed are collected from the tree too soon, they will not germinate; but if collecting is delayed too long, they will be shed from the tree. Recent studies have shown that sugar maple seeds generally reach their maximum germination potential when the moisture content has dropped below 145 percent (dry weight basis) or the samaras have turned a yellowish green color. This information will enable seed collectors to gather sugar maple seeds at the right time and be assured of at least 95 percent germination. NE (1067).

497. Pine seedlings planted on pumice soils in central Oregon frequently grow slowly. Results of an experiment with lodgepole and ponderosa pine seedlings grown in boxes containing representative soil profiles indicate that both the physical and nutrient characteristics of the pumice layer may limit seedling development in the field. This suggests that auger planting, which has been effective on these soils, may be superior

to machine planting because the auger breaks up and mixes the pumice layer with material above and below it. PNW (1068).

498. The needle concentration of minor elements, necessary for optimum Monterey pine growth is not known. A PL 480 project in Spain delineated zones of deficiency, sufficiency, and toxicity for iron, zinc, and copper in the needles of Monterey pine seedlings. Optimum growth occurred when there were 40 to 150 parts per million (ppm) of Fe, 10-200 ppm of Zn and 2-8 ppm of Cu in the needles. Visual deficiency and toxicity symptoms were also described. These findings are important in the attempt to quantify field nutrient levels in this valuable species. WO (1069).

499. The relationship of chlorophyll content to photosynthesis in developing leaves is not well understood. Selected biochemical factors associated with photosynthesis were investigated in the expending leaf zone of young cottonwood plants in controlled environment rooms. The photosynthetic mechanism of newly formed leaves is inoperative until critical levels of Calvin cycle enzymes are synthesized, even though considerable total chlorophyl may be present. This demonstrates the importance of protein metabolism to the onset of photosynthesis during leaf expansion in cottonwood. NC (1070).

500. The physiological, biochemical, and anatomical correlations between leaf and stem growth in the zone of leaf development are not well understood. Changes in nitrogen content and soluble protein, and peroxidase patterns as determined by electrophoresis were compared for leaves and internodes below the growing tip in eastern cottonwood in Wisconsin. These biochemical parameters were found to be closely related to changes in organ size and physiology. Such research in basic physiology provides new insights into the roles of various biochemical substances during the period of rapid development in plants. NC (1071).

501. Mycorrhizae, the symbiotic union of selected soil fungi and tree roots, are essential for vigorous and healthy growth of many forest tree species. Proceedings of a recent conference on this subject summarized the current information on this complex relationship. It is apparent from numerous investigations of a number of different mycorrhizal relationships that mycorrhizae increase tree growth by increasing nutrient content through greater absorption of infected roots and by increasing the utilization of the less available forms of minerals. Such information is proving valuable in improving our planting procedures, especially with nonnative species, where the mycorrhizal fungi may have to be added at time of planting. WO (1072).

502. Fertilizers are used in Christmas tree plantations to stimulate rapid growth and to promote a luxuriant green foliage. Research in North Carolina showed that planted 3-year-old Fraser fir and white pine can be fertilized with ammonium nitrate at the rate of 1 ounce for small trees and 2 ounces for trees more than 4 feet tall. Larger quantities resulted in excessive nitrogen concentration in the foliage (4 to 5 percent) and killed the trees. SE (1073).

503. Some physiological studies in plants require accurate identification of the comparative stage of development of vegetative tissues between different individuals. Growth models were developed for eastern cottonwood in Wisconsin that mathematically relate leaf length, leaf area, leaf dry weight, number of vessels per internode, and number of vessels per petiole to a previously developed quantitative index, the plastochron index that defines the relation between physical measurements and other growth events or processes. These models can be used to adjust plants of different developmental stages to a standardized morphological time scale and to predict developmental processes and events from simple, nondestructive measurements. NC (1074).

504. Under present regeneration techniques many species are grown on a wide variety of sites. Potted 1-year-old loblolly pines had the same distribution of dry matter under environmental conditions ranging from one-third to full sunlight. However, soil moisture stress appeared to inhibit shoot growth to a greater degree than root growth. Results suggest that loblolly pine trees adapt well to changing environments. SO (1075).

505. Plant response often varies with season of fertilizer application. Three-year-old slash pine seedlings grown in potted Beauregard silt loam responded equally to fall and spring applications of nitrogen in terms of height growth, total weight, and nitrogen recovery. These results suggest that season of application is not a critical factor in nitrogen nutrition of slash pine. SO (1076).

506. Forest tree nurseries producing Douglas-fir seedlings in Oregon and Washington often apply nitrogen fertilizers to improve growth. An experiment at the Webster State Forest Nursery near Olympia, Washington, showed that seedling growth in the nursery, and performance after outplanting, were better when the nitrogen was supplied in the form of urea or nitrate rather than as ammonium. Choice of the nitrogen source is therefore clearly evident, but because of the complexity of other related factors, each nursery should determine the best fertilization regime to use by making an on-the-site investigation. PNW (1077).

507. It is difficult to study the annual formation of xylem because of high variability among individual cells within a tree and the effects of cell damage due to sampling technique. Research in Poland (PL 480) shows that the effect of cell variability is greatly reduced if samples are taken from several trees instead of a single specimen and averaged for analyses. When studying xylem formation of Scots pine throughout the season, the effects of previous wounding (through sampling) on cells are avoided by taking samples at least 1 cm apart at intervals up to 21 days. WO (1078).

508. Plants vary in their efficiency to transform CO_2 into organic matter. A research team (PL 480) found that two ecotypes of Scots pine, originating from highland and lowland regions of Poland, exhibited different patterns of dry matter production, photosynthesis, and respiration. Results also supplied information on the different patterns of needle

growth in the top, middle, and basal parts of shoots. This information aids in the interpretation of data on physiological processes occurring within a plant and is important for sampling representative needle material. WO (1079).

6. GROWTH AND YIELD

509. The role of thinning is changing in the management of slash pine. In this short-rotation species, mean annual increment culminates from 25 to 27 years of age in stands of 500 trees per acre or less. Primary product objective should determine initial spacing, and thinning under this condition assumes little importance as a regulator of growth in rotations up to 30 years. This concept is important for the management of superior trees because they are too valuable to plant at spacing that requires early thinning. SE (1080, 1081).

510. In unmanaged second-growth stands, codominant and intermediate yellow birch poles are usually crowded out by more dominant species. Through moderate to heavy crown release, diameter growth and crown vigor of these trees were greatly improved. Epicormic branching was also increased by release but was not serious because most of it occurred above the butt log. These results can mean more valuable yellow birch sawlogs for the birch-using industry. NC (1082).

511. Suitable volume tables were lacking for the two cedars of southeastern Alaska--western redcedar and Alaska-cedar. Separate cubic-foot volume tables and combined board-foot tables are now available for old-growth stands of these two valuable species. PNW (1083).

512. Since most old-growth northern hardwood timber in New England has been cut, future timber supplies will come from second-growth even-aged stands. How will financial yields change? A clearcutting in 90-year-old even-aged northern hardwoods produced a variety of products with delivered value of $758 per acre. Clearcutting a nearby uneven-aged, old-growth stand produced $688 per acre. Even-aged stands containing high-quality paper birch in mixture with species of low quality will peak in product value when the short-lived paper birch mature. Thus financial yields from old-growth stands can be equalled or exceeded by yields of much younger even-aged stands that followed clearcutting. NE (1084).

513. Knowledge of primary productivity of coniferous forest ecosystems is important for determination of nutrient cycling and storage within the systems. A 26-year-old western hemlock stand on the Oregon Coast had a total biomass and current net annual production of 231.1 and 36.2 metric tons per hectare, respectively. Of the total mass, 65 percent was in stems, 9 percent each in the leaves and branches, and 17 percent in the roots. This production rate is high when compared with other forest types analyzed in eastern Asia and other parts of the world. PNW (1085).

514. Western larch is an important species in the Blue Mountains of northwestern Oregon, but there is little information available to guide thinning operations in pole-sized stands in this area. The 5-year growth responses of a 32-year-old pure even-aged western larch stand thinned to a wide range of stocking levels showed that maximum merchantable volume growth was reached at a basal area of about 90 to 100 square feet per acre. The results of this study can be used to derive preliminary guidelines on the stocking to leave after the first thinning in such stands. PNW (1086).

515. Treefern is a major component of rain forests in Hawaii. Studies of the growth habits of the most common treefern, hapu'u-pulu, indicate that its annual rate of growth is much slower than reported earlier--less than 0.1 inch in diameter and less than 2.0 inches in height. Forest protection and management activities should recognize that if we hope to maintain this resource, much longer rotation cycles will be needed than previously thought feasible. PSW (1087).

516. New management guides were developed to maximize recoverable growth in vigorous, mature (70 to 150 years), even-aged, Douglas-fir stands in western Oregon and Washington--a class of stand that will probably exist for another 50 years. Through intermediate harvest cuttings, it was possible to recover 81 percent of the potential growth (net growth plus normal mortality) for up to 38 years from single thinnings and for 18 years with two thinnings. Thinning resulted in substantial reduction in losses caused by bark beetles (61 percent), windthrow (30 percent), breakage (33 percent), and suppression (46 percent). Thinning in this forest type should extend into the upper crown canopy, and should leave 60 to 85 percent of normal basal area. PNW (1088).

7. FOREST MEASUREMENTS

517. The accuracy of two optical dendrometers (Zeiss telemeter teletop, Barr and Stroud) were compared with measurements taken by climbing loblolly pines in central Louisiana. Estimates of tree volume, surface areas, length, and sum of diameters for entire tree did not differ significantly from caliper measurements. Both dendrometers overestimated measured volume by about 1 percent. SO (1089).

518. Foresters often need quick reliable estimates of stand volumes. A stand volume equation is now available for even-aged lodgepole pine stands in Montana and Idaho. The equation ($V = 0.46952\,[BH] - 32.79$) gives direct estimates of total gross cubic-foot volume (V) of stands from measurements of stand basal area (B) and average height of dominant trees (H). INT (1090).

519. Forest researchers and managers are constantly in need of better ways to estimate standing timber. In a recent study of alternative relative measures of stand density for Pacific Northwest Douglas-fir, a simple sum of diameters to a fixed power ($\Sigma D^{1.55}$) when used alone, provided

the simplest of several diameter-based measures. Unlike basal area, it has a direct biological interpretation as a sum of expected tree areas per unit of forest area. This power function can be used as a measure of stand density which does not require concurrent determinations of age, site index, or average diameter. PNW (1091).

520. A modified computer program (STX 1-11-71) for processing dendrometer measurements of standing trees is now available. It allows combining 3P sampling and dendrometry with multistage sampling where first stage may involve area sampling or point sampling. It also substitutes a Fortran sort for system sort/merge and provides for within-tree sorting and subtotaling by quality grades. The new program will facilitate the analyses of tree measurement data. SE (1092).

521. Although leaf surface area is an important indicator of tree growth, accurate measurements have been difficult to obtain. Regression estimates of the needle-area growth of loblolly pine were obtained from periodic measurements of the green length and the average fascicle length of the foliated portion of individual branches. This technique is nondestructive and applicable to physiological studies of any conifer. SE (1093).

522. Sample selection of individual logs with probability proportional to predicted volume (3P) in three tests of log scaling indicated coefficients of variation for logs of 17 to 27 percent. This suggests that 3P log scaling may be efficient in providing precise estimates to total volume at small cost, and it may prove superior to sample log scaling methods now in use. PNW (1094).

523. Yield tables commonly available for black spruce have in the past been inadequate to reflect the productive potentials of even-aged stands growing on typically organic soils in northern Minnesota. New yield tables are now available which describe the growth and yield relationship of Minnesota black spruce to site index, age, and basal area density. This will permit more accurate forecasting of growth of this useful species. NC (1095).

524. Present yield tables are not adequate estimators of quaking aspen growth and yield. To assist in the management of this species, new yield tables applicable to aspen in northcentral Minnesota have been established which provide equations for predicting total cubic foot volume, ratio of merchantable volume to total volume, and future stand diameter, height, and basal area. These yield tables also include information for total stand volume and merchantable stand volume to 3- and 5-inch top diameters. NC (1096).

525. Sampling with unequal probabilities of selecting a sample unit frequently can result in increased efficiency in estimating population totals. To facilitate drawing samples using this method, a computer subroutine is provided that identifies the units in the sample, calculates their sampling probability, and summarizes the distribution of this probability over the entire population for use in subsequent estimates of the population

total and its variance. This procedure has improved the efficiency of surveys of insect damage, of tree defects, and of compartments used in timber management planning. INT (1097).

526. Rounding the independent variable in linear regression will generally bias the least squares estimators of the regression coefficient. A rule for rounding has been derived to retain sufficient measurement precision so that the resulting bias will be negligible. SE (1098).

8. MANAGEMENT PLANNING

527. A new management guide for black spruce in the Lake States was published in Minnesota. Summaries of information on soil site relations, associated vegetation, methods and requirements for reproduction, stand development, yield and 10-year net growth, and damaging agents are provided. It also includes recommended management practices for pulpwood and Christmas trees stands, and requirements for successful broadcast burning. NC (1099).

528. Data relating the effect of site, initial spacing, and age to growth and yield of slash and loblolly pine are sparse for cutover areas in the West Gulf Region. Basal areas, cordwood and cubic foot volumes, average dbh, and diameter distribution are summarized by spacing-site index categories for 14-year-old slash pine and 17-year-old loblolly pine planted in central Louisiana. Results can be used to select optimum planting densities for various sites and management objectives and in projecting plantation growth and rotation length for various products. SO (1100, 1101).

529. Yield tables for managed stands are essential guides for forest managers. Improved field procedures and computer programs have been developed for ponderosa pine in the Black Hills of South Dakota and Wyoming to meet the need for more realistic simulations of stand growth, response to intermediate cuttings, and reproduction cuttings by any of the even-aged management systems. RM (1102).

530. A comprehensive procedure for computation of yield tables for dwarf mistletoe-infested, managed, even-aged stands of lodgepole pine in Colorado and southern Wyoming has been developed to help forest managers evaluate and choose between the alternative practices of sanitation thinning, no treatment (with hope that the stands may eventually become merchantable) or stand destruction and regeneration. RM (1103).

531. Expanding use by the public, coupled with the need for increasing amounts of wood, requires intensified management of oak forests. Neither of the standard management systems--selection cutting or even-aged management by large blocks--is acceptable for all purposes. Group selection is applicable on small woodlands, but on large holdings the system would have to be modified to provide for large groups to be identified, treated, and controlled by areas, and with the cut regulated by volume.

Research is needed to develop and demonstrate a system that has the advantages of group selection cutting but that will also adequately provide for orderly regulation of yields--not just for timber but also for water, wildlife, and all other products of the forest. NE (1104).

9. MAPLE SYRUP PRODUCTION

532. The selection and propagation of sugar maple trees superior in sap sugar concentration is of primary importance to the future of the maple syrup industry. Forty-four sugar maples have been tested and selected from among 21,000 trees growing from Maine to Pennsylvania and are now being clonally propagated and are growing in the Burlington, Vermont, area. These trees with sap sugar content as high as 10.6 percent will form the basis for future progeny and clonal tests for superior selections and for the establishment of sugar maple seed orchards. NE (1106).

533. It would be useful to the maple syrup industry if high producing sap trees could be easily recognized. When a number of characteristics of individual sugar maple trees were measured during one season, both sap volume yield and total sugar production were correlated with tree and crown size. But contrary to popular belief, there was little evidence of a relationship between tree characteristics and sap sugar concentration, an essential factor for the low-cost production of maple syrup. NE (1105).

534. Maple syrup producers have long needed information relating to the optimum stocking of sugar maple trees for sap production. A sugarbush stocking guide has now been prepared which suggests the minimum number of trees per acre for sugarbush stands of various diameter classes that will allow for maximum crown development. The guides are designed for use in developing sugarbushes from forest grown stands, for thinning in existing over-crowded sugarbushes, and for spacing recommendations in planting new sugarbush stands. NE (1107).

10. NAVAL STORES

535. A tree breeder interested in manipulating the monoterpene composition of longleaf pine and slash pine oleoresins can now be assured of some degree of success. Recent genetic studies of the monoterpenes of both clonal and control-pollinated individuals of these species demonstrated that the composition of cortical oleoresin is under strong genetic control. By careful selection and breeding of trees high in selected desirable monoterpenes, it will be feasible to both modify and improve the composition of the oleoresin. SE (1108, 1109).

536. Levopimaric acid is a potentially useful chemical occurring in the oleoresin of slash and longleaf pines. Recent studies with slash pine have shown that high oleoresin yielders tend to have a high levopimaric

acid content. It is thus feasible to increase both the oleoresin yields and levopimaric acid content in the same genetic improvement program by screening only the high oleoresin trees for levopimaric acid. SE (1110).

537. The difficulty of obtaining cortex resin for comparative studies in species variation from corkbark fir (A. lasiocarpa var. arizonica) led to an attempt to determine whether phloem and cortex resins are sufficiently alike to analyze together. The two kinds of resin proved to be similar qualitatively but quantitatively different, with cortical resin generally higher in limonene and lower in the other components. It can be concluded that resin from the two tissues should be analyzed separately in future chemosystematic studies. PSW (1111).

B. Breeding Improved Trees

1. DISTRIBUTION AND CLASSIFICATION OF FOREST TREES

538. Taxonomy and nomenclature of the Pinus flexilis complex, an important group of forest trees in the West, has remained conjectural for many years. On the basis of new detailed observations on herbarium specimens and seedling tests, this group can be divided into two species P. flexilis James on the North, and P. strobiformis Engelm. on the South. This information is of importance to the resource manager in selecting the correct species for planting in the Southwest. INT (1112).

539. The vegetation of many parts of California has changed dramatically in the last few decades through natural succession, logging, and urbanization. Fifty-seven elevational profiles of nearly half of the State's vegetation as it existed in 1930 have now been assembled. Beside providing a useful historical record, the profiles illustrate the influence of such ecological factors as elevation, exposure, slope, and maritime influence on the composition of the dominant vegetation. To the resource manager, this is a useful history for future land use planning. PSW (1113).

540. A comprehensive handbook has been compiled which describes and illustrates the 33 trees and 94 shrubs native to Alaska. Also included are range maps, a key for identification of the woody plants during summer and winter, and a large color map showing the types of tundra and forest. It will be a valuable reference for anyone interested in the preservation and wise use of Alaska's natural resources. PNW (1115).

2. INHERENT VARIATION

541. Recent reports from southern Mississippi, Louisiana, and Arkansas suggest that the incidence of dwarfing could be a limiting factor in slash x shortleaf pine hybrid breeding programs. Current investigations

have shown that dwarfing was affected by shortleaf pine pollen source, but on the basis of available evidence dwarfing was probably a consequence of hybridization rather than the combination of genes for dwarfing. Though serious to the tree improver, the dwarfing problem now can be largely eliminated by standard nursery grading procedures which select only normal seedlings for planting. SO (1122).

542. When trees from distant seed sources are planted, they do not have the same growth rate as those from local parents. Recent remeasurement of test plantings of ponderosa pine from different elevational sources established in 1938 have shown that specific gravity decreased as elevation of parents increased and when ponderosa pine from any source is planted at high elevations in the Sierra Nevada, the wood will have lower specific gravity. These results suggest that midelevation sources outplanted at about 3,000 feet could give the desirable combination of high volume yield and high specific gravity wood. PSW (1117).

543. An analysis of enzymes from germinating pine embryos revealed certain enzymes that are inherited as single genes. These enzymes which can be easily identified are now being used as "genetic markers" in studies of gene migration and natural selection in natural forest tree populations. Such studies clarify the mode of inheritance in forest trees and provide guidelines for future breeding programs. PSW (1116).

544. Seeds produced from self-fertilization tend to produce slower growing seedlings. Therefore the degree to which coastal Douglas-fir can set sound seed following self-pollination is an important factor in managing seed orchards of this species for the mass production of improved seeds. Following controlled polinations, self-fertility was found to be generally low, with the median tree yielding 7.5 percent as many seeds following self- as following cross-pollination. This low level of selfing should pose no serious problem to the seed orchard manager. PNW (1125).

545. Knowledge of the variation in selected wood characteristics of sweetgum provides the tree breeders with important tools for developing an improvement program for this species. Recent investigations with first-year seedlings from different geographic sources, grown under controlled conditions, demonstrated that fiber tracheid length was longest, and wood specific gravity was lowest in sources from the lower latitudes. These population differences suggest the feasibility of modifying wood quality through genetic manipulation of selected seed sources. WO (1127).

546. The diverse conditions under which Norway spruce grows suggest a great amount of genetic variation in this useful European species. Studies in Poland of 25 local Polish seed sources found considerable variation in seed size, weight, and mineral content, as well as marked differences in seedling growth and mineral requirements. Both elevation and latitude were correlated with mineral content and seedling growth. With further testing, guides for the selection of seed sources best suited for the United States can be developed. SO (1118, 1119).

547. There is an urgent need for higher production of quality wood on short rotations for reconstituted wood products, veneer logs, and sawtimber. To meet this demand will require trees such as hybrid poplars with inherently rapid growth to justify much more intensive culture than has been economically feasible in the past. The distribution, taxonomy, variation, and site requirements of eastern cottonwood are now summarized and evaluated for those planning to use this species. NE (1123).

548. To meet the increasing demand for hardwood fiber, the cultivation and management of faster growing hardwood varieties, as hybrid poplars, is taking on new importance in the United States. Two Italian scientists have now demonstrated that superior poplar hybrids have a longer growing period, higher photosynthetic rate, and a relatively smaller number of large vessels than their slower growing parent species. Collectively, these features of hybrids could account for their superior growth. This information will aid in the more rapid identification of superior trees for the poplar improvement program in the United States. WO (1126).

549. Trees selected for vigor and form can also serve as a basis for an oleoresin improvement program. Studies of slash pine showed that high oleoresin yields were positively correlated with tree vigor. It would be possible and desirable in future programs to select high oleoresin yielding trees from trees originally selected for vigor and form, thus possible gains in all three traits could be obtained with a common selection program. SE (1121).

550. To obtain greater wood volume on fewer acres, it would be desirable to be able to select and grow tall stocky trees. Recent tests with ponderosa pine seedlings suggest that this may be possible. Diameters at average seedling height of 12.5 inches among 41 families were 22 percent greater from stocky parents than from slender parents, though average heights were not significantly different. These investigations are being continued to determine if this relationship remains true for the adult types. PNW (1124).

551. The importance of racial variation is often overlooked in regenerating slash pine within the species range. Growth results from 15 outplantings of 69 seed sources show that seed for planting slash pine in areas north of central Florida should be collected mainly in South Georgia. Selection for oleoresin yield and resistance to fusiform rust may best be accomplished through selection of individual trees. SE (1120).

3. INSECT-DISEASE RESISTANCE

552. Brown spot needle blight is a serious seedling disease that prolongs the grass stage of longleaf pine and discourages the regeneration of this valuable species. Approximately one-third of 227 plus-tree progenies from wind pollination, grown for 2 years in central Louisiana, showed strong evidence of resistance to brown spot. Selected trees showed a high degree of disease resistance and will be useful in tree breeding programs. SO (1128).

553. Profitable management of slash and loblolly pines depends upon incorporating rust resistance into otherwise improved planting stock. Phenotypic selection in heavily damaged stands is an efficient means for locating new sources of resistance. When this concept was recently tested, progenies from all rust-free parents were more resistant than seedlings representative of the general population. Additional resistance can be obtained by progeny testing of these initial selections. SO (1129).

554. A decade ago breeding for resistance was considered only a promising means of reducing losses to forest insects and diseases. Convincing examples have since demonstrated its practicality, and a summary and evaluation of recent accomplishments and descriptions of their implications with special emphasis on southern pine resistance to fusiform rust has been prepared. On the basis of these evaluations, new approaches and areas of research meriting increased effort can be recommended for consideration by research managers. SO (1130).

555. In the South, the need to produce more timber at lower cost on fewer acres has led to increasing use of intensive cultural practices such as site preparation, cultivation, and fertilization. Although these practices increase growth, they have also been shown to increase the incidence and severity of fusiform rust in slash pine. Recent studies have demonstrated that regardless of cultural treatment, the more resistant strains within the species remained consistently less infected than their more susceptible counterparts. Nevertheless, intensive cultural practices should be used with caution in areas where rust is a problem. SO (1131).

556. Cottonwood leaf beetle larvae defoliate willows as well as poplars. However, there is the possibility of developing a degree of protection to this insect by growing more resistant trees. A test in Mississippi showed that defoliation among 37 clones of black willow ranged from a low of 21 and a high of 95 percent, while two clones of the cross, Salix babylonica x S. alba and three clones of the sandbar willow had less than 10 percent defoliation. These tests clearly indicate that a degree of resistance does exist and it will be possible for the tree improver to select for it. SO (1132).

557. Loblolly pine, the most important commercial pine species in the southeastern United States, is susceptible to damage by southern fusiform rust. A number of trees with a high degree of resistance to this disease have now been located in Florida, Louisiana, and southwestern Mississippi. Stands nearest the Gulf Coast in Alabama and Mississippi were least resistant and resistance increased gradually to the north and west. These results provide a workable guide for the efficient selection for rust-resistant loblolly pine for future plantings within the study area and probably outside it as well, since the area covered is representative of most of the loblolly range. SO (1133).

4. TREE BREEDING METHODOLOGY

558. Efficient techniques for controlled pollination in white oak are essential for its genetic improvement. In tests conducted in both Mississippi and Connecticut, successful hybrids have now been produced with both

fresh pollen and pollen stored for 1 year. The use of stored pollen will enable white oak breeders to accelerate their genetics programs since they can make rangewide crosses. SO (1134).

559. An understanding of the mechanism of the chemical stimulation of rooting would be useful in the vegetative production of genetically superior trees. Studies in India with Salix, Populus, and Hibiscus have clearly demonstrated that the effectiveness of common rooting hormones is influenced by the nutritional status of the cutting. For successful rooting there is a need for a balance between the applied hormone and the carbohydrate content of the cutting, and this balance varies between trees of the same species as well as between species. WO (1135, 1136, 1137).

560. Methods are needed to determine if variation in competitive ability exists in slash pine and how to test for it. A genotype x environment stability procedure which subjected related families to severe nursery conditions of limited space and moisture proved useful for isolating differences between families in growth. Some families grow better under stress than other families. Volume production of plantations could be improved by planting only trees first selected for their better competitive ability at close spacing in the nursery. SO (1138).

C. Improving Use of Wood

1. WOOD AND TIMBER QUALITY

561. The anticipated shortage of timber has stimulated interest in accelerating wood production through rise of intensive cultural practices. The effect of prescribed levels of irrigation and fertilization on the wood quality of 6-year-old slash pine has been investigated and is now reported. Primary quality characteristic investigated was specific gravity, which was reduced by fertilization. Effect on secondary qualities such as grain orientation, clear length between whorls, number and diameter of branches, and percentage of latewood was also observed. FPL (812).

562. Hardwood lumber suffers loss in both volume and degrade during the air-drying process, but sawmills and wood-using plants have never known the magnitude. Detailed tabulated information is now available for 10 of the more important hardwood species showing how green lumber changes in volume and grade when seasoned to the rough air-dry condition. Average volume losses vary from 2 to 7 percent depending on species and grades. Availability of such data will enable estimates of losses to be made without regrading and remeasuring following air drying. NE (788).

563. Estimates of tree quality through use of tree grades have become of increasing interest to owners, buyers, and sellers of timber. An interim hardwood tree grade covering factory lumber, recently developed and approved by the Forest Service, provides grade volumes for yellow birch, red maple, and black oak trees. Tree grade specifications as well as associated lumber grade volumes are presented so that by applying current lumber prices the tree's value for lumber can be estimated. NE (794).

564. Question invariably arises as to what percent of the total cubic-foot content of a tree is used following harvest, and how much is left in the woods, the processing mill, or elsewhere. Averages developed from summaries of information gathered from various sources are now presented and provide some of the answers for western softwoods. Results show that about 75-85 percent of the total cubic-foot content of the tree is used, indicating that efficiency in the western softwood industry is perhaps greater than normally realized. PNW (789).

565. Recent limitations placed on burning have fostered an increased interest in the possibilities of developing economic procedures for manufacturing bark products. Research aimed at utilization of bark needs to consider the effect of variation and modification of bark structure on product properties and the possibility of developing a classification system based on external appearance. Research findings did not result in a system that could correlate anatomical characteristics of bark with external appearance, but several sources of bark variation that could be used to separate bark into quality classes, as they might affect bark product quality, were isolated. PNW (806).

566. Due to the increasing demand for lumber and impending possible timber shortages, white fir, once considered an "inferior" species is now in a position of being an important source of lumber. This has resulted in an increasing need for up-to-date information on grade recovery and other related aspects for this species. Details regarding grade and volume changes in surfacing and drying of over 43,000 board feet of white fir timber and analysis of results obtained are now available. Information of the type included is important to public and private agencies for timber appraisal and quality evaluation as well as to the lumber industry for updating processing procedures. PNW (803).

567. Detailed information on suitability of local timber resources for veneer production is needed to make sound decisions on location of new plywood facilities. Extensive information on veneer recovery by grades and sizes and yield by log grade and size has now been developed for Black Hills ponderosa pine, a species not previously utilized for commercial plywood production. Valuable resource and utilization guidelines are presented for considering the feasibility of establishing plywood plants in the Black Hills area. RM (816).

568. A variety of cultural treatments have been investigated for the purpose of enhancing timber growth and increasing yield per acre. A study on 7-year-old plantation-grown sycamore involving techniques of fertilization, thinning, and a combination of both, indicated greater species response to thinning than to fertilization in both radial growth and wood properties. Growing space becomes the limiting growth factor in sycamore after 4 years (planted 8 x 8), and forest managers should recognize the importance of growing space in attempting to maximize fiber production based on short rotations. SE (808).

569. The practice of purchasing southern pine timber on a weight basis has raised serious question as to possible seasonal variation in weight per unit volume due to variation in moisture content. Results of a recent study indicate a single weight factor can be applied to loblolly and slash pine trees found growing in the same location. Since there are no seasonal changes in weight, seasonal adjustments in the weight scaling factor are not necessary. SE (811).

570. Log and tree grade systems for eastern white pine have been developed and approved as standard for all Forest Service operations where grading of eastern white pine is necessary. Because of extreme variability in eastern white pine quality, these grading systems are necessary for accurate and consistent stratification of sawlogs and trees into distinct value classes for appraisal for sale or inventory purposes. Use of these grades provides buyer and seller with a better tool for estimating values and affords sawmill operators a device for better control of raw material entering the mill. NE (812).

571. Systems for determining yields of dimensions from top grades of walnut and alder lumber have been developed. Basic information for each grade for random-width material is presented with adjustments for determing yields in given widths. This allows yield and cost comparisons to be made using various grades and grade mixes to provide information on the most economical choice for specific cutting orders. Savings of several hundred dollars are obtainable in typical cutting orders through correct grade selection. FPL (809, 810).

572. The high-pitched scream or sirenlike sound of a saw in a sawmill or secondary manufacturing plant hurts the ears and may be detrimental to the workers' health. A solution to the screaming saw problems is now available. It involves a simple method of cutting symmetrically placed expansion slots in the rim of the sawblade. High, natural-frequency vibrations are thus suppressed to reduce sound within tolerable limits. FPL (798).

573. Production of lumber from logs involves, essentially, fitting rectangles into a circle, with the key to maximum lumber yield from any given size log being width of opening face or position of the first cut. A computer program has been developed which determines, for each log diameter, the width and position of the first saw cut made on the log which will maximize the yield of lumber products. Results indicate use of the best opening face (B.O.F.) system can enable sawmillers to recover at least 10 percent more than they are currently obtaining from small logs. FPL (792, 957).

574. Guidelines and preliminary rules for estimating volume of unsound wood associated with defects have now been developed for koa and ohia logs on the island of Hawaii. Frequent inconsistencies previously occurred between cruisers and graders since there was no good basis for decision. Evaluation of volume loss associated with defect indicators such as butt scar, conks, branch stubs, fork, and the like now provides for accurate reduction. PSW (786).

575. Stake tests on pressure and nonpressure treated southern pine have been under way in decay and termite exposure sites in Mississippi, Wisconsin, Louisiana, Florida, and the Canal Zone since 1938. Most recent observations indicate superficial treatment (3-minute dipping and brushing with preservatives such as creosote, copper napthenate, penta, and the like) adds from a few months to 4 years to untreated stake life. Some waterborne preservatives have provided less protection than preservative oils and others show results that compare favorably. FPL (834).

576. Accurate prediction of equilibrium moisture content (EMC) of wood is important in controlling wood product quality. A formula for predicting masses of data has been developed based on sorption theory and data. Results agree well with tabulated readings. Average deviation of calculated from tabulated values is less than 0.13 percent moisture content and deviation is never more than 0.9 percent. FPL (862).

577. Esthetically desirable and durable wood shingles and shakes have been restricted, in some applications, because of performance under fire conditions. Suitable fire retardancy would improve shingle and shake utility and insure consumer confidence and, to this end, numerous fire retardant treating systems have been evaluated. Four systems have shown excellent promise in providing fire retardant effectiveness following lengthy exposures to leaching and weathering: three chemical impregnation treatments and one impregnation followed by a coating. Economy and treatment levels--to establish optimum effectiveness--are yet to be determined, but basic screening of numerous possible systems has been accomplished. FPL (838).

578. Excessive water in paint film or in the wood under the film can cause blistering, peeling, or other unsightly failures of the wood finish. The types of damage caused by unwanted water or water vapor, the source, the manner in which it gains ingress to the film or wood, and possible remedies are discussed in a report written by the Forest Products Laboratory. Information is particularly helpful to homeowners in identifying failures, understanding the causes, diagnosing the problem, and taking corrective measures. FPL (871).

579. Dry lumber has many advantages in the manufacture of most wood products, but drying processes, regardless of system used, are costly and time consuming. A comprehensive manual on air drying practices and procedures, incorporating information resulting from recent research, is now available to assist mill and plant managers, yard foremen, lumber handlers, and others in analyzing their air drying practices and achieving maximum efficiency. Resulting faster drying and improved quality benefits both producer and consumer through lowered cost and reduction of loss or degrade. FPL (859).

580. Drying costs for oak, probably the most important United States hardwood, are high since it is very difficult to dry rapidly without considerable loss due to degrade. A preliminary Forest Service study investigating several possible methods of reducing degrade and drying costs of oak has been completed and suggests possible drying economies that may be attainable. Further study and analysis of commercial feasibility and applicability of suggested methods is necessary, but procedures that could prove beneficial to oak processors, either singly or in combination, are outlined. FPL (875).

581. Black walnut lumber continues to be highly prized for furniture, paneling, gunstocks, and the like, but the supply of high-quality black walnut trees is critically scarce. Much valuable black walnut dimension can be economically produced from short tree sections, tops, large branches, and other logging residues customarily left behind during logging operations. A procedure using bolter saws to produce short flitches which are then processed into dimension parts shows much promise in augmenting diminishing walnut supplies through more efficient utilization and improvement of forest environment through reduction of unsightly slash. NC (829, 872).

582. Aspen lumber machines easily, but fuzzy or chipped grain often results when conventional (parallel-to-the-grain) knife planers are used. Cross-grain planing produces superior surfaces, since defects are shallower than those produced by conventional planing, and subsequent processing and waste can be reduced.

Flakes suitable for panel products (particleboard, etc.) can also be manufactured simultaneously by cross-grain planing of aspen at 6 percent moisture content, thus requiring less conditioning prior to processing into particleboard. NC (868).

583. Frequency of chipped grain has previously been used as a basis for determining suitable rake angle in the planing of hard maple. Recent studies indicate that perhaps depth of machining defects rather than frequency may be a better guide to determining proper rake angle for surfacing many hardwoods. Proper rake angle, producing shallow defects, provides for reduced loss of material in further processing to achieve surface smoothness. NC (870).

584. Literature on southern pine bark structure is limited with only surface characteristics descriptions of some species being available. A comprehensive detailed study of the bark of the ten southern pines has been conducted, reporting anatomical and physical characteristics of the various bark layers and cells, as well as comparative properties of bark of the involved species. With bark utilization of timely importance, an analysis of bark structure could provide a basis for developing possible future uses. SO (839).

585. A recent process for rapid drying of southern pine studs from small logs or veneer cores has seen only limited application because of cutting size restrictions.

A more broadly applicable system of drying under restraint in a high-temperature kiln produces substantially straighter, higher grade studs with strength essentially equal to conventionally dried studs. The high-temperature schedule takes less than one-fourth the time and one-half the total energy required by the low-temperature schedule, and provides better resistance to subsequent warp under adverse conditions than conventionally dried studs. SO (842, 843).

586. The potential for cutting wood with a laser beam offers a number of advantages over conventional machining processes, including narrow kerf, no sawdust, minimal noise, and the like. In cutting southern pine wood with an air-jet assisted, carbon dioxide laser, maximum feed speed differs with material thickness, specific gravity, and moisture content. However, feed speed along the grain does not differ from feed speed across the grain. Laser cutting efficiency is low compared to conventional circular saw cutting, but other considerations offset this. SO (852).

587. The technology for formulating phenol formaldehyde resin adhesives for plywood has been well established, for the most part, by empirical means. Though the chemistry of the resins has been widely studied, little published data relating resin properties to wood adhesion is available. Information and data are now available relating bond quality and some of the physical and chemical properties of adhesives. Adequate definition of such relationships could lead to the eventual development of criteria for controlling both formulation and performance of glues. SO (840).

588. Southern pine bark is utilized in a number of industrial products and such uses will increase, but probably not fast enough to prevent disposal problems if incineration of waste is outlawed. The most promising process for large-volume disposal appears to be in use as a fuel. Technology and economics indicate it may be feasible to burn southern pine bark efficiently to generate steam in electric plants with little emission of pollutants. (846).

589. Southern pine wood can be successfully steam bent if the bending jig incorporates a flexible metal strap with a mechanism to apply uniform end compression load during bending. Steaming periods of 10 to 20 minutes per inch of thickness appear adequate. Edge-grained, fast-grown, low-specific gravity wood without cross grain provides the best stock for successful bends. SO (848).

590. The southern pines are an important national resource, and it is estimated they will provide the major source of softwood timber in years to come. Significant opportunities exist for increased utilization in both harvesting and manufacturing. The next decade will likely see rapid maturation of recent developments such as tree shears, chipping headrigs, whole tree utilization, new lumber and plywood manufacturing technology, and the like. SO (845).

591. A computer program has been developed that accepts basic field inventory from sample trees and determines stand potential for a number of individual primary products and combinations of products. The program can be used to grade or classify trees or sections of trees for all possible products or for individual products of greatest value in a specified order of preference. This provides the manager of a diversified timber operation with a tool to evaluate timber inventory data for the entire array of potential lumber products with possible conversion alternatives. RM (836).

592. Specific gravity is the simplest and most useful single index to suitability of wood for many uses. The presence of extractives in resinous species, however, may increase both magnitude and variability of this index beyond that warranted by the cell wall substance alone. This provides a chance of error in estimates of strength characteristics or pulp yields. Mean specific gravity of southwestern ponderosa pine is reduced approximately 12 percent by extractive removal, and an equation has been developed by which extracted specific gravity may be estimated based on measured unextracted specific gravity. RM (818).

593. To avoid possible surface checking, the moisture content of large laminated members at the time of fabrication should approximately equal that of the equilibrium moisture content (EMC) of the area where the timber is to be used. Equilibrium moisture contents measured seasonally for 3 years in laminated timbers exposed under a variety of exterior and interior conditions from South Dakota to Arizona (Rocky Mountain area) remained in a narrow range of 6.6 to 10.5 percent. Laminated timber producers should therefore fabricate at a moisture content of about 8 percent for laminated timbers to be used in that area. RM (854).

594. Oak has an advantage over other wood and nonwood materials for three industrial products: railroad crossties, returnable pallets, and laminated truck flooring. These products are the largest and fastest growing markets for oak. Producers of oak lumber should keep these products in mind in production planning, since the sizes used in their manufacture range from large to small and narrow, providing opportunity for improved utilization of logs. NE (857).

595. Machine-driving of wooden and steel guardrail posts is an accepted procedure, and wood has now been shown to be superior to steel in resisting damage when driven under adverse conditions such as rock-filled roadbeds. Blunt-bottomed wood posts produce cores of compressed earthen material at the base, which reduces required driving energy and protects the post from damage. Information should be of special importance to developers of State highway specifications. NE (831).

3. WOOD CHEMISTRY AND FIBER PRODUCTS

596. The quantity and composition of waste paper in combined or mixed refuse collected by the City of Madison, Wis., over a period of a year have been determined. Paper made up nearly 47 percent of the total

over the period. The waste paper contained 41 percent groundwood and 59 percent chemical pulp. Physical properties of papers made from reclaimed fiber were similar to those made from groundwood. FPL (894).

597. Research on the potential of waste wood and bark manufacturing residues as animal feeds continues. Alkali treatment of aspen sawdust renders it as digestible as hay, according to assay tests. The digestibility of aspen sawdust, aspen bark, and alkali-treated aspen sawdust by goats was determined. Results yielded apparent digestibilities of 41 percent for aspen sawdust, 52 percent for alkali-treated aspen sawdust, and 50 percent for young aspen bark. Use of these wood wastes as ruminant roughage and energy source provides a high-value outlet and diminishes disposal problems. FPL (890).

598. The chemical structures and quantitative distribution of new resin acids in the needles and young bark of slash pine have been determined. One of these resin acids, imbricataloic acid, comprises 24 to 64 percent of the needle resin acids. This information on needle extractives will be useful for evaluating logging wastes as a potential source for naval stores. FPL (902).

599. The oxidative decomposition of wood fiber polysaccharides such as cellulose is one of the major obstacles to the adoption of oxygen as a universal pulping agent in place of sulfur and chlorine, which are major causes of pollution in conventional pulping and bleaching operations. These oxygen-wood pulping reactions continue to be studied. Degradation products have been identified and quantified. Another new concept to suppress cellulose oxidation with potassium iodide was examined. Degradation was prevented, but the system appears impractical. FPL (891, 898, 899).

600. The annual production of bark residues from wood products manufacturing has been estimated at 400 million cubic feet. Bark could become an important source of useful chemicals. New terpenoid compounds have been identified in lodgepole pine bark. Six new derivatives of nordehydroabietane have been isolated from jack pine and western white pine barks. Anticopalic acid has been found to be a major constituent of the bark of western white pine and eastern white pine. These chemicals from bark are not yet of economic significance in themselves but may become significant in combination with naval stores or other bark or wood utilization operations. FPL (896, 897, 911, 913).

601. Pulpwood chips undergo significant deterioration in outdoor storage piles (approximately 1 percent per month) due to cell respiration, heat, micro-organisms, chemical action, and in some cases spontaneous combustion. Initial heating is caused by living cell respiration. Chemical reactions have greater significance as chip pile temperatures rise. Further testing of green liquor regenerated from kraft pulping wastes has shown that it provides effective control of deterioration in aspen chips as well as pine. FPL (886, 887, 903, 904).

602. Hardboards differ considerably in properties depending upon manufacturing variables. Eight variables in the manufacture of high-density, wet-formed hardboards were analyzed. Wood species proved statistically the most important factor in affecting dimensional stability with pressing temperature and method of refining also having an influence on this property. Type of resin had the greatest effect on strength and stiffness. Effects of pulp freeness, type of refiner, forming-water temperature, resin amount, pressing temperature, and tempering were also examined. This quantified analysis will assist manufacturers in using new raw materials such as forestry and agricultural wastes more effectively in producing better quality boards. FPL (906).

603. Most properties of paper are strongly dependent on moisture conditions; therefore, the specific relationships between paper properties and moisture content are of primary importance. A basic relationship exists between specimen equilibrium moisture content and the tensile strength properties of linerboards. Cyclic changes in relative humidity produce greater deformation and reduced serviceability of paper than does a constant, relative humidity environment. Stacked fiberboard containers are more likely to fail in an uncontrolled relative humidity environment than in a controlled, constant relative humidity environment, even though the average moisture content may be higher in the latter environment. FPL (877, 878).

604. The properties of paper and other woodpulp products are influenced by the properties of fiber and subfiber structures. Increased knowledge of cellulose and fiber structures will provide better understanding of the deformation behavior of paper. It has been proposed that wood fibers are formed with built-in tension and that fibrils are transformed during pulping. Pulping releases restraint of fibrils, permitting them to contract longitudinally and undergo perimeter reduction and S-helical twisting. This implies molecular rearrangements within the fibril which would contribute to changes in paper properties. FPL (907, 908, 909).

4. WOOD ENGINEERING

605. Compressive strength, vitally important in corrugated shipping containers, is closely related to edgewise compressive strength and bending stiffness of the combined board. Methods of determining the former were developed, but ways of accurately determining the latter were not known. Two methods of determining the bending or flexural stiffness of the combined board through determinations of component part properties have now been developed; both provide accurate, satisfactory results. These methods provide a quality control tool and means of predicting fiberboard properties that could otherwise be determined only through extensive and expensive empirical testing. FPL (932).

606. Control of finger joint location in tension laminates of commercially produced laminated timbers is not readily feasible, and the effect of such joints on strength of timbers must, therefore, be known. Tests on

large glued timbers indicate beams with finger joints at the midlength of the tension laminations (the most critical area) are as strong and stiff as those without finger joints in the same region. Results provide more accurate definition of factors affecting large glued beam strength and are essential in developing effective specifications. (938).

607. Producers and users alike need up-to-date information on efficient manufacturing practices to achieve maximum utilization of the wood used in the manufacture of over 125 million pallets per year. Pallet manufacture consumes almost 10 percent of our annual lumber production.

Results of recent research have been incorporated in a report which covers basic and fundamental wood concepts, characteristics, methods of fastening, pallet fabrication, construction, and design. The report provides a reference for the manufacturer promoting efficient raw material use as well as the purchaser interested in quality goods and satisfactory performance. FPL (922).

608. Evaluation of all possible combinations of nails of a variety of metals, shapes, and sizes used with numerous species of wood to establish design loads is an almost endless task. A FS study has derived a simple theoretical expression involving shear load and joint slip of laterally loaded smooth round nails which accounts for various properties of nail and wood. Results of the study can be used to establish design loads for nails to permit use at maximum efficiency without evaluating all combinations of nails and species. FPL (945).

609. Southern pine plywood used as exterior siding provides maximum racking strength, but affords a relatively poor base for paint or other surface coatings. A study has shown that southern pine plywood and paintable southern hardwood face veneers can be combined to produce a strong panel with superior finishing properties. This new panel shows excellent promise as an efficient and economical plywood siding or sheathing-siding material for houses or other structures. SE (924).

610. Open wood decks provide desirable outdoor living area and spaciousness in home design, but special precautions are necessary to avoid deterioration under adverse exposure conditions. The Forest Service has prepared a comprehensive guide describing proper materials, design, construction details, treatments, and finishes that insure years of satisfactory deck performance. Illustrations of "good" as well as "poor" practices are included to assure proper wood use. PNW (915).

611. Average mechanical properties of the clear wood of the four major southern pine species have been reestimated using a double sampling technique. Revised estimates of bending strength of slash and shortleaf are slightly higher than previous estimates, while those for longleaf and loblolly are slightly lower. Most recent results also indicate values for modulus of elasticity in bending and maximum crushing strength are lower than previously estimated for loblolly, longleaf, and slash. Variability is also greater than previously expected. FPL (917).

612. Oak as a species grouping is plentiful, but much of the supply is low in grade and of the "scrub" species. Recent technological developments have done much to remove certain stigmas associated with use of oak as a raw material for reconstituted panel products for which "scrub" species are suited. Several current commercial fiber products are being made from reconstituted oak and present research under way will result in other efficient uses. FPL (937).

613. Timber bridges are not obsolete as often assumed, and are still economic structures for many secondary road systems. Properly designed and adequately pressure treated with preservatives, they will give many years of low-maintenance service. Advanced design concepts under investigation will provide further economics and greater efficiencies in timber utilization. FPL (941).

5. MISCELLANEOUS

614. Wood has served from the earliest days of history as an efficient and economical construction material. It has remained competitive even though research and the technological improvements have been at a relatively low level. Many technological advances and more efficient uses of wood are attainable through research and implementation of results. A renewable resource that can be produced into products with low energy consumption and little environmental degradation, wood is likely to assume a more prominent role in the future. FPL (953, 955, 956).

(For an additional item see paragraph 3.)

D. Marketing Under-Used Species and Residues

615. Wood residues produced by secondary manufacturing plants in 11 midwestern States totaled about 241 million cubic feet of fine and coarse materials in 1970. Of this total, 55 percent was sold or used for industrial fuel, 11 percent was given away (mostly for animal bedding or mulch), and 34 percent was burned or dumped as waste. The relatively small volumes generated by many individual firms and the lack of nearby markets are the main reasons why more of this material is not marketed for some economic use. NC (27).

616. As part of an analysis of opportunities for increasing wood manufacturing and employment opportunities in the Black Hills, veneer recovery from Black Hills ponderosa pine sawtimber trees was studied. Results from the 144 trees sampled show a veneer recovery in grades and proportions more than sufficient to manufacture at least 3/8-inch C-D plywood. It is believed that these sample results are fairly representative of recoveries probable from the Black Hills ponderosa pine log resource. RM (36).

617. Bark residues continue to be a serious disposal problem to the sawmill industry. One potential use is as a mulch when seeding disturbed soils on strip-mined areas, highway roadbanks and similar areas. Preliminary experiments in West Virginia using power mulchers (straw blowers) for large-scale application of either raw or processed bark showed satisfactory results. Since labor required to feed bark into the blower was found to be excessive, some sort of mechanized feed system must be developed to make use of bark power mulchers economically feasible. NE (28).

618. A prerequisite to developing economic uses for bark residues is a reasonably accurate estimate of material available and its location. A study in western Montana provides estimates of bark produced at plywood and sawmill operations in four areas as defined by the regional transportation system. INT (31).

619. Prices paid for primary wood manufacturing residues (chips and sawdust) used for fiber products in Washington and Oregon show a pattern of gradually rising prices over the period 1956-1970. The trend pattern was not uniform, but consisted of sharp rise followed by periods of relatively little change. PNW (29).

620. Maryland, Pennsylvania, and West Virginia pallet manufacturers produced 6 million pallets (5 percent of national production) and used 150 million board feet of hardwood lumber in 1968. This study of the tristate pallet industry includes information on raw material purchases, sources of supply, and marketing patterns by size of establishment. NE (32).

621. Wood residues, particularly large chips, play an important role in the electric smelting of certain ferro-alloys. A survey of the electrometallurgical industry in 1970 showed a total wood consumption of about 796,000 tons (green weight). Since much of the industry is concentrated in or adjacent to the Appalachian region, this industry provides a limited but worthwhile outlet for sawmill wood residues, low-grade roundwood, and logging residue. NE (35).

E. Supply, Demand, and Price Analysis

622. A pilot study of wood products used in the construction of apartment buildings in Pennsylvania for which construction contracts were awarded in 1965 showed the average use of lumber per unit to be 3,334 board feet. Plywood use averaged 1.16 square feet (3/8-inch basis) per square foot of floor area and 1,211 square feet per housing unit. Both hardboard and particleboard usage primarily was in millwork and averaged 156 and 97 square feet respectively per housing unit constructed. This pilot study has been expanded to provide similar information for total U.S. apartment construction in 1969. WO (59).

623. In 1970, the United States wood preserving industry treated over 260.3 million cubic feet of wood products. This was an increase of 2.7 percent over the volume treated in 1969. Poles, crossties, lumber, and timbers accounted for over 212 million cubic feet, or about four-fifths of the total. Of the remainder, fence posts and piling were most important. WO (50).

624. The rapid rise in log exports from the West Coast during the 1960's has created widespread divergency of opinion as to impacts and consequences. An examination of economic theory regarding exports reviews benefits and costs, and discusses guidelines for the formulation of log export policies. PNW (51).

625. While domestic consumption of hardwood plywood nearly tripled from 1960 through 1969, practically all of this market went to imported materials. A study of trends in hardwood plywood production and market outlook concludes that if domestic producers are to share in this growing market, they should consider including prefinishing of imported hardwood plywood in their production mix. NC (54).

626. Over one-fifth of all wood household furniture manufactured in the United States, is produced in North Carolina. In 1968 this segment of the furniture industry purchased approximately 300 million board feet of domestic lumber, 27 percent of which originated from within the State. Use of red oak, soft maple, and mixed pine species increased greatly over the volumes used in 1963, but the use of black walnut, sycamore, yellow-poplar, and the hickories declined significantly. SE (41).

627. Municipal fire laws and regulations frequently restrict the use of natural Christmas trees in public buildings. A sample of 80 major cities in the United States disclosed that three will not permit the use of natural trees in public places and 61 require that a tree must be fireproofed before use in schools, hospitals, or other places of public assembly. NE (49).

628. A quarterly analysis of production, prices, employment, and trade in Northwest forest industries provides current information on lumber and plywood production and prices; employment in the forest industries; international trade in logs, lumber, and plywood; volume and average prices of stumpage sold by public agencies; and other related items. PNW (44, 45, 46, 47).

629. Furniture "rounds" are a valuable market for better grade hardwood logs. Firms producing furniture rounds cannot afford inefficient material allocation or processing techniques. In a South Carolina study, operations research techniques were used to evaluate processing strategy under alternative choices of material inputs (log sizes), processing constraints, and product requirements. Operations research as demonstrated by this study can be a valuable aid in improving profitability of existing plants or evaluating investments in new plant facilities. SE (48).

PUBLICATION LIST AND INDEX

The index and the following list of Forest Service research publications are also printed as a separate to the Research Accomplishments 1972 report.

The first number(s) following the index term refers to the narrative statement in the Research Accomplishments 1972 report. Numbers in parentheses refer to the publication list.

Each publication is followed by an abbreviation denoting the Forest Service research unit best able to supply additional, detailed information and copies of the 1,138 publications listed. Abbreviations and addresses of the research units are:

PNW - Director,
Pacific Northwest Forest and Range Experiment Station
809 NE 6th Avenue, P.O. Box 3141
Portland, Oregon 97208

PSW - Director,
Pacific Southwest Forest and Range Experiment Station
1960 Addison Street, P.O. Box 245
Berkeley, California 94701

INT - Director,
Intermountain Forest and Range Experiment Station
507 25th Street
Ogden, Utah 84401

RM - Director,
Rocky Mountain Forest and Range Experiment Station
240 West Prospect Street
Fort Collins, Colorado 80521

NC - Director,
North Central Forest Experiment Station
Folwell Avenue
St. Paul, Minnesota 55101

NE - Director
Northeastern Forest Experiment Station
6816 Market Street
Upper Darby, Pennsylvania 19082

SE - Director
Southeastern Forest Experiment Station
Post Office Building, P.O. Box 2570
Asheville, North Carolina 28802

SO - Director,
Southern Forest Experiment Station
T-10210 Federal Building
701 Loyola Avenue
New Orleans, Louisiana 70113

FPL - Director,
Forest Products Laboratory
North Walnut Street
P.O. Box 5130
Madison, Wisconsin 53705

ITF - Director,
Institute of Tropical Forestry,
University of Puerto Rico
Agricultural Experiment Station Grounds
P.O. Box AQ
Rio Piedras, Puerto Rico 00928

WO - Deputy Chief for Research
Forest Service
U.S. Department of Agriculture
Washington, D.C. 20250

PUBLICATIONS

FOREST ECONOMICS AND MARKETING RESEARCH

Forest Economics Research	Publication Number
Methods of financial evaluation and planning	1-6
Timber growing economics	7-15
Multiple-use economics	16-19
Impacts on forest industry and regional economies	20-26
Forest Products Marketing Research	
Marketing underused species and residues	27-36
Supply, demand, and price analysis	37-61
Marketing--general	62-86
Forest Survey	
Forest inventory	87-103
Timber utilization and production	104-126
Survey techniques	127-131

FOREST ENVIRONMENT RESEARCH

	Publication Number
Forest Recreation Research	
Wilderness ecology and management	132-138
Managing the visual environment	139-142
Socioeconomic values of outdoor recreation	143-150
Campsite design and management	151-153
Analyzing recreation resources and use	154-166
Range Management Research	
Evaluating range resources	167-169
Characteristics and forage values of range plants	170-173
Livestock and grazing management	174-177
Range ecology	178
Range improvements	179-181
Watershed Management Research	
Controlling soil erosion	182-194
Utilizing solid wastes	195
Chemicals in the forest environment	196-207
Noise abatement	208-209
Improving water yields	210-244
Managing watersheds	245-269
Watershed rehabilitation and damage prevention	270-283
Water quality	284-292
Measuring environmental parameters	293-308
Wildlife Habitat Research	
Evaluating and improving wildlife habitat	309-315
Integrating wildlife and other land uses	316-320
FOREST FIRE AND ATMOSPHERIC SCIENCES RESEARCH	
Fire prevention, hazard reduction, and prescribed burning	321-344
Fire management methods and systems	345-360
Forest fire science	361-385
Remote sensing methods	386-397
Fire and forest meteorology	398-407
FOREST FIRE AND ATMOSPHERIC SCIENCES RESEARCH	
Forest Disease Research	
Root diseases	408-440
Stem cankers	441-463
Dwarf mistletoes	464-474
Vascular wilts	475-482
Foliage diseases	483-489
Air pollution	490-494

	Publication Number
Wood deterioration	495-518
Forest fungi	519-537
Miscellaneous studies	538-572
Forest Insect Research	
Life history and ecology of insects	573-654
Insect physiology, nutrition, and rearing	655-684
Biological control of insects	685-705
Chemical control of insects	706-732
Silvicultural and mechanical control of insects	733-735
Host resistance to insects and tree physiology	736-741
Insect sampling and survey methods	742-753
Forest pest management	754-757
FOREST PRODUCTS AND ENGINEERING RESEARCH	
Forest Engineering Research	
Improving engineering systems	758-785
Forest Products Utilization Research	
Wood and timber quality	786-816
Wood products and wood processing	817-875
Wood chemistry and fiber products	876-914
Wood engineering	915-951
Miscellaneous	952-962
TIMBER MANAGEMENT RESEARCH	
Trees to enhance the environment	963-967
Natural regeneration	968-984
Silvicultural methods	985-992
Ecological relationships	993-1001
Site evaluation and soil improvement	1002-1021
Artificial regeneration	1022-1045
Stand improvement	1046-1057
Animal damage	1058-1064
Growth requirements	1065-1079
Growth and yield	1080-1088
Forest measurements	1089-1098
Management planning	1099-1104
Maple syrup production	1105-1107
Naval stores	1108-1111
Distribution and classification of forest trees	1112-1115
Inherent variation	1116-1127
Insect-disease resistance	1128-1133
Tree breeding methodology	1134-1138

FOREST ECONOMICS RESEARCH

Methods of financial evaluation and planning

1. Dutrow, George F., and William Balmer. 1971. Financial evaluation of management techniques. In Southeast. Hardwoods Symp. Prod., p. 90-97. Southeast. Area, State and Priv. Forest., USDA Forest Serv., Atlanta, Ga. (SO)

2. Gieske, Michael H., and Ron S. Boston. 1971. DAMID, a discounting analysis model for investment decision. USDA Forest Serv. Res. Note RM-200, 12 p. (RM)

3. Hennes, LeRoy C., Michael J. Irving, and Daniel I. Navon. 1971. Forest control and regulation...a comparison of traditional methods and alternatives. USDA Forest Serv. Res. Note PSW-231, 10 p. (PNW)

4. Lundgren, Allen L. 1971. Ranking investment alternatives--a new look. J. For. 69(9): 568-573. (NC)

5. Lundgren, Allen L., and Dennis L. Schweitzer. 1971. NCRETURN computer program for evaluating investments revised to provide additional information. USDA Forest Serv. Res. Note NC-111, 4 p. (NC)

6. Lundgren, Allen L. 1971. Tables of compound-discount interest rate multipliers for evaluating forestry investments. USDA Forest Serv. Res. Pap. NC-51, 142 p. (NC)

Timber growing economics

7. Anderson, Walter C. 1971. Who will grow the trees--and where? For. Farmer 30(7): 14-15. (SO)

8. Anderson, Walter C., and Sam Guttenberg. 1971. Investor's guide to converting southern oak-pine types. USDA Forest Serv. Res. Pap. SO-72, 10 p. (SO)

9. DeBald, Paul S., and Joseph J. Mendel. 1971. Determining the rate of value increase for oaks. In Oak Symposium Proceedings, USDA Forest Serv. Northeast. Forest Exp. Sta., p. 142-151. (NE)

10. Dutrow, George F. 1971. Economic implications of silage sycamore. USDA Forest Serv. Res. Pap. SO-66, 9 p. (SO)

11. Guttenberg, Sam. 1971. The southern hardwood situation. Am. Pulpwood Assoc. Tech. Pap., p. 33-37. June. Also as A look at the south's hardwood situation. Pulpwood Prod. 19(3): 14, 16. (SO)

12. Guttenberg, Sam. 1971. Setting rotation age. La. State Univ. 20th Annu. For. Symp. Proc., p. 5-9. (SO)

13. Siegel, William C. 1971. Logging roads and the federal income tax. For. Prod. J. 21(10): 12-14. (SO)

14. Schallau, Con H. 1971. Who says accelerated roadbuilding pays? J. For. 69: 279-280. (PNW)

15. Yoho, James G., George F. Dutrow., and James E. Moak. 1971. What it costs to practice forestry. For. Farmer 30(7): 42-50. Also in For. Farmer 28(11): 20-24, 26, 28, 30-31. (SO)

Multiple-use economics

16. Boster, Ron S. 1971. Ground water and the environmental movement. Ground Water 9(1): 2-4. (RM)

17. Navon, Daniel I. 1971. Timber RAM... a long-range planning method for commercial timber lands under multiple-use management. USDA Forest Serv. Res. Pap. PSW-70, 22 p. (PSW)

18. Wikstrom, John H., and S. Blair Hutchison. 1971. Stratification of forest land for timber management planning on western National Forest. USDA Forest Serv. Res. Pap. INT-108, 38 p. (INT)

19. Worley, David P., and James H. Patric. 1971. Economic evaluation of some watershed management alternatives on forest land in West Virginia. Water Resour. Res. 7(4): 812-818. (NE)

Impacts on forest industry and regional economies

20. Dutrow, George F. 1971. Disequilibrium model for stumpage price analysis. For. Sci. 17: 246-251. (SO)

21. Gansner, David A., Donald W. Seegrist, and Gerald S. Walton. 1971. A technique for defining subareas for regional analysis. Growth and Change 2(4): 20-24. (NE)

22. Guttenberg, Sam. 1971. The price instability of lumber and plywood: its causes and effects. In Futures trading in plywood and lumber--a profit margin insurance, p. 3-9. La. State Univ. Coop. Ext. Publ. 1630. (SO)

23. Holley, Daniel L., Jr. 1971. Predicting regional shifts in plywood and lumber production. Ga. Coll. Bus. Econ. Q. 1(1): 40-53. (SO)

24. Kaiser, Harold F., Jr. 1971. Productivity gains in forest products industries. For. Prod. J. 21(5): 14-16. (SO)

25. Kaiser, Harold F., Jr., and George F. Dutrow. 1971. Structure and changes in the southern forest economy, 1958-1967. USDA Forest Serv. Res. Pap. SO-71, 18 p. (SO)

26. Larsen, David N., and David A. Gansner. 1971. Pennsylvania's private woodland owners - A study of the characteristics, attitudes, and actions of an important group of decision makers. USDA Forest Serv. Res. Pap. NE-219, 17 p. (NE)

FOREST PRODUCTS MARKETING RESEARCH

Marketing underused species and residues

27. Carpenter, E. M. 1971. Wood residues--a cost or market potential? Woodworking and Furniture Digest 73 (6): 36-38 (NC) [1]

28. Emanual, D. M. 1971. Power mulchers can apply hardwood bark mulch. USDA Forest Serv. Res. Note NE-135, 6 p. (NE)

29. Hamilton, T. E. 1971. Prices of primary manufacturing residues. Forest Industries 98(12): 25-26. (PNW)

30. Huyler, N. K. 1971. The effect of method of sawing low-grade red oak logs on lumber yield and mill profit. M. S. thesis, West Virginia University, Morgantown, W. Va., 93 p. (NE)

31. Lowery, D. P., J. P. Krier, and J. R. Host. 1971. Bark residues in western Montana. USDA Forest Serv. Res. Note INT-140, 4 p. (INT)

32. Mount, P. R. 1971. The Appalachian pallet industry. Northern Logger and Timber Processer 20(2): 22-23, 60-61. (NE)

33. Scott, E. G., and B. C. Bearce. 1972. A hardwood-bark-sawdust compost for greenhouse pot flower production. For. Prod. J 22(1): 36-39. (NE)

34. Wartluft, J. L. 1971. Measuring bark residues from red oak saw logs. South. Lumberman 223 (2776): 167-168. (NE)

35. Wartluft, J. L. 1971. The use and market for wood in the electrometallurgical industry. USDA Forest Serv. Res. Pap. NE-191, 12 p. (NE)

[1] This publication begins the list for Forest Products Marketing Research.

36. Yerkes, V. P., and R. O. Woodfin, Jr. 1972. Veneer recovery from Black Hills ponderosa pine. USDA Forest Serv. Res. Pap. RM-82, 23 p. (RM)

Supply, demand, and price analysis

37. Anderson, R. B. 1971. Southern furniture manufacturers increasing in-plant production of dimension stock. Woodworking and Furniture Digest 73(3): 30-32. (NE)

38. Anderson, R. B., and P. E. Sendak. 1971. Use of hardwood dimension stock by the southern furniture industry. USDA Forest Serv. Res. Pap. NE-225, 27 p. (NE)

39. Applefield, M. 1971. Use of hardwoods in residential construction. Woodworking and Furniture Digest 73(5): 28-30. (SE)

40. Applefield, M. 1971. Wood and the North Carolina furniture industry. Woodworking and Furniture Digest 73(12): 28-30. (SE)

41. Applefield, M. 1971. Sources of lumber for furniture plants in North Carolina, 1968. Southeast. Forest Exp. Sta., Asheville, N.C., 6 p. (SE)

42. Baumgartner, D. C. 1971. The changing market for wood materials used in farm structures. USDA Forest Serv. Res. Pap. NC-61, 6 p. (NC)

43. Beuter, J. H. 1971. Timber value--a matter of choice. USDA Forest Serv. Res. Pap. PNW-118, 12 p. (PNW)

44. Darr, D. R. 1971. Production, prices, employment, and trade in Northwest forest industries, fourth quarter 1970. Pacific Northwest Forest and Range Exp. Sta., Portland, Oreg., 57 p. (PNW)

45. Darr, D. R. 1971. Production, prices, employment, and trade in Northwest forest industries, first quarter 1971. Pacific Northwest Forest and Range Exp. Sta. Portland, Oregon., 58 p. (PNW)

46. Darr, D.R. 1971. Production, prices, employment, and trade in Northwest forest industries, second quarter 1971. Pacific Northwest Forest and Range Exp. Sta., Portland, Oreg., 62 p. (PNW)

47. Darr, D. R. 1971. Production, prices, employment, and trade in Northwest forest industries, third quarter 1971. Pacific Northwest Forest and Range Exp. Sta., Portland, Oreg., 54 p. (PNW)

48. Fasick, C. A., and J. D. Lawrence. 1971. An operations research application to furniture round production. For. Prod. J. 21(4): 46-52. (SE)

49. Garrett, L. D. 1971. City fire codes become threat to natural Christmas tree sales. Amer. Christmas Tree J. 15(3): 5-7. (NE)

50. Gill, T. G., and R. B. Phelps. 1971. Wood preservation statistics, 1970. USDA Forest Serv. in cooperation with American Wood Preservers' Assoc., 34 p. (WO)

51. Hamilton, T. E. 1971. Log export policy: theory versus reality. J. For. 69(8): 494-497. (PNW)

52. Harpole, G. B. 1971. A simple technique to increase profits in wood products marketing. USDA Forest Serv. Res. Note PSW-242, 4 p. (PSW)

53. Host, J. R. 1971. A quick reference for comparing rail freight costs of softwood lumber items. USDA Forest Serv. Res. Note INT-141, 7 p. (INT)

54. Lindell, G. R. 1971. Hardwood plywood--output and outlook. Woodworking and Furniture Digest 73(4): 38-40. (NC)

55. Lindell, G. R., and G. C. Klippel. 1972. The Kitchen cabinet market--big business for panel industries. Plywood and Panel XII(8): 14-15. (NC)

56. Martens, D. G. 1971. Hardwood?--Carpet--or Tile? USDA Forest Serv. Res. Pap. NE-200, 25 p. (NE)

57. Pendeleton, T. H., and L. D. Garett. 1971. The Winston-Salem survey: factors that influence Christmas tree sales. The Christmas Merchandiser, Aug. 1971, p. 12-14. (NE)

58. Phelps, R. B. 1971. Wood products use trends in single-family houses. For. Prod. J. 21(7): 10-13. (WO)

59. Reid, W. H., M. G. Wright, and G.D. Lewis. 1971. Wood products used in the construction of apartment buildings in Pennsylvania. USDA Forest Serv. Res. Pap. WO-14, 12 p. (WO)

60. Robinson, V. L. 1971. An econometric analysis of the softwood lumber market, 1947-1967. Ph.D. Thesis, University of Georgia, Athens, Ga., 151 p. (SE)

61. Sendak, Paul E. 1972. The national pure maple syrup consumer survey. Proceedings of the Eighth Conference on Maple Products. ARS 73-73 (EMN Public. No. 3618), p. 50-56. (NE)

Marketing - general

62. Adams, E. L. 1972. SOLVE: A computer program for determining the maximum value of hardwood sawlogs. USDA Forest Serv. Res. Pap. NE-229, 54 p. (NE)

63. Adams, E. L. 1971. Effect of moisture loss on red oak sawlog weight. USDA Forest Serv. Res. Note NE-133, 4 p. (NE)

64. Adams, E. L. 1971. Instructions for using the SOLVE use packet. USDA Forest Serv. NE Area State and Private Forestry, Upper Darby, Penna., 20 p. (NE)

65. Applefield, M. 1971. Use of building codes and zoning regulations in Florida. Florida Municipal Record 44(11): 9, 11-12, 14. (SE)

66. Baumgras, J. E. 1971. Configuration of Appalachian logging roads. USDA Forest Serv. Res. Pap. NE-198, 16 p. (NE)

67. Baumgras, J. E. 1971. Logging-machine recording instruments--a new management tool for loggers. South. Lumberman 223(2776): 102-104. (NE)

68. Bond, R. S. 1972. Labor intensity and demand in the Northeastern primary wood-processing industries--part 1. Northern Logger and Timber Processer 20(7): 16-18, 32. (NE)

69. Bond, R. S. 1972. A labor situation analysis of the Northeastern primary wood-processing industries--part 2. Northern Logger and Timber Processer 20(8): 18-19, 28-29, 31. (NE)

70. Dickerhoof, H. E. 1971. The underfloor plenum: an alternative to concrete slab and crawl-space construction. USDA Forest Serv. Res. Pap. SE-85, 24 p. (SE)

71. Dickerhoof, H. E., C. A. Fasick, and W. G. Wagner. 1971. New market opportunities for wood floor construction in Southern homes. The South. Lumberman 223(2776): 109-112. (SE)

72. Harpole, G. B., and H. E. Dickerhoof. 1971. Floor foundations: preferences of new home buyers in six Southwestern United States markets. USDA Forest Serv. Res. Pap. PSW-73, 12 p. (PSW)

73. Harpole, G. B., and H. E. Dickerhoof. 1971. Floor foundations: preferences of architects and builders in six Southwestern United States markets. USDA Forest Serv. Res. Pap. PSW-74, 11 p. (PSW)

74. Hogan, W. G., and S. M. Brock. 1971. The effect of workmen's compensation on the logging and sawmilling industries in the Northeast. West Virginia Univ., Appalachian Research Series Bul. 17, 37 p. (NE)

75. Large, H. R., H. A. Core, G. R. Wells, and W. E. Duggan. 1971. Hardwood flooring yields from Appalachian red oak lumber. The University of Tenn., Agr. Expt. Sta., Bul. 484, 20 p. (NE)

76. Lawrence, J. D. 1971. An analysis of the role of mobile homes in satisfying defined levels of potential demand for housing in the United States. Ph.D. Thesis University of Georgia, Athens, Ga., 140 p. (SE)

77. Lindell, G. R. 1971. Maple flooring--how architects view it. USDA Forest Serv. Res. Note NC-109, 4 pp. (NC)

78. Lindell, G. R., and L. T. Hendricks. 1972. The changing hardwood veneer and plywood industry of Michigan and Wisconsin. USDA Forest Serv. Res. Pap. NC-72, 8 p. (NC)

79. Lohr, C. J., B. G. Hansen, and J. W. Nolley. 1971. Primary wood industries of Kentucky, 1971--a utilization summary and directory. Kentucky Dep. Nat. Resources, 87 p. (NE)

80. Martin, A. J. 1971. The relative importance of factors that determine log-hauling costs. USDA Forest Serv. Res. Pap. NE-197, 15 p. (NE)

81. Miller, W. C. 1971. Physical distribution of oak strip flooring in 1969. USDA Forest Serv. Res. Pap. NE-207, 31 p. (NE)

82. Miller, W. C. 1971. Distribution of maple strip flooring. USDA Forest Serv. Res. Pap. NE-215, 24 p. (NE)

83. Miller, W. C. 1971. Distribution of parquet flooring during 1969. USDA Forest Serv. Res. Pap. NE-218, 11 p. (NE)

84. Nolley, J. W. 1971. Christmas tree marketing: an annotated bibliography. Amer. Christmas Tree J. 15(2): 25-29. (NE)

85. Sendak, P. E. 1971. Statistical cost study of pallet production. Ph.D. Thesis University of Massachusetts, Amherst, Mass., 120 p. (NE)

86. Timson, F. G. 1972. Sawlog weights for Appalachian hardwoods. USDA Forest Serv. Res. Pap. NE-272, 29 p. (NE)

FOREST SURVEY

Forest inventory

87. Bellamy, T. R. 1971. Forest statistics for Southeast Georgia 1971. Southeast. Forest Exp. Sta., USDA Forest Serv. Resource Bull. SE-21, 34 p. (SE)[1]

88. Beltz, R. C., and D. F. Bertelson. 1971. Timber resource statistics for midsouth counties, 1971. USDA Forest Serv. Resource Bull. SO-31, 27 p. (SO)

89. Bertelson, D. F. 1971. Growth components of Arkansas forests. USDA Forest Serv. Resource Note SO-114, 3 p. Also in Cross Ties 52(11): 28-31. (SO)

90. Christopher, J.F. 1971. Alabama forests being appraised. Ala. Forest Prod. 14(7): 35-36. (SO)

91. Christopher, J. F. 1971. Alabama's timber supply and its measurement. In 10th Auburn Forest Forum Proc., 42-44. Coop. Ext. Serv., Auburn Univ. (SO)

92. Essex, Burton L. 1972. Forest area in Wisconsin Counties, 1968. USDA Forest Serv. Res. Note NC-135, 4 p. (NC)

93. Ferguson, Roland H., and Neal P. Kingsley. 1972. The Timber Resources of Maine. USDA Forest Serv. Resource Bull. NE-26, 129 p. (NE)

[1] This publication begins the list for Forest Survey.

94. Hedlund, A. 1971. Arkansas delta forest: a vanishing resource. Forest Farmer 30(4): 13-14, 17. (SO)

95. Hedlund, A., and J. M. Earles. 1971. Forest statistics for east Tennessee counties. USDA Forest Serv. Resource Bull. SO-26, 24 p. (SO)

96. Hedlund, A., and J. M. Earles. 1971. Forest statistics for middle Tennessee counties. USDA Forest Serv. Resource Bull. SO-29, 24 p. (SO)

97. Hedlund, A., and J. M. Earles. 1971. Forest statistics for Tennessee counties. USDA Forest Serv. Resource Bull. SO-32, 58 p. (SO)

98. Hedlund, A., and J. M. Earles. 1971. Forest Statistics for Tennessee Plateau counties. USDA Forest Serv. Resource Bull. SO-27, 21 p. (SO)

99. Knight, H. A. 1971. Increase in Florida's available timber supply. Forest Farmer 30(12): 10-11. (SE)

100. Knight, H. A., and J. P. McClure. 1971. Florida's timber, 1970. USDA Forest Serv. Resource Bull. SE-20, 48 p. (SE)

101. Pfeifer, Ray E., and John S. Spencer, Jr. 1971. The growing timber resource of Michigan--the Northern Lower Peninsula. Michigan Dep. Nat. Resources, 112 p. (NC)

102. Sternitzke, H. S. 1971. Timber trends in Tennessee's Appalachians. South. Lumberman 223(2776): 131-132. (SO)

103. Van Sickle, C. C. 1971. Latest survey shows: Arkansas produces more timber on less land. Forest Farmer 30(9): 9, 12, 14. (SO)

Timber utilization and production

104. Beltz, R. C. 1971. Average hauling distance for Midsouth pulpwood unchanged since 1960. TAPPI 54: 579-580. (SO)

105. Beltz, R. C. 1971. Midsouth pulpwood prices, 1970. South. Pulp Pap. Manuf. 34(10-A): 22. (SO)

106. Beltz, R. C. 1971. Southern pulpwood production, 1970. USDA Forest Serv. Resource Bull. SO-28, 22 p. (SO)

107. Bertelson, D. F. 1971. Tennessee forest industries. USDA Forest Serv. Resource Bull. SO-30, 27 p. (SO)

108. Blyth, James E. 1971. Lake States pulpwood production reaches new high in 1970. USDA Forest Serv. Res. Note NC-126, 3 p. (NC)

109. Blyth, James E. 1971. Primary forest products industry and industrial roundwood production, Michigan, 1969. USDA Forest Serv. Resource Bull. NC-12, 12 p. (NC)

110. Blyth, James E. 1971. Pulpwood production in the North Central Region by county, 1970. USDA Forest Serv. Resource Bull. NC-13, 22 p. (NC)

111. Blyth, James E. and William A. Farris. 1972. Iowa saw-log production and sawmill industry, 1969. USDA Forest Serv. Res. Note NC-136, 4 p. (NC)

112. Blyth, James E., and Leonard K. Gould. 1971. Kansas saw-log production jumps 38 percent from 1964 to 1969. USDA Forest Serv. Res. Note NC-128, 2 p. (NC)

113. Bones, James T., and Teresa M. Bowers, 1971. Wood residues--how much are we recovering? Northern Logger 20 (3), 2 p. (NE)

114. Bones, James T., and David R. Dickson. 1971. Pulpwood production in the Northeast--1970. 34 p. (NE)

115. Gedney, Donald R., and John W. Henley. 1971. Utilization estimates for western softwoods--trees, logs, and residues. USDA Forest Serv. Res. Note PNW-158, 8 p. (PNW)

116. Gedney, Donald R. 1971. Forest products residues--Their volume, use, and value, Part 2, Residues from primary manufacture. Forest Industries 98(12), 2 p. (PNW)

117. Ginnaty, Thomas P., Jr. 1972. Veneer-log production and receipts--north central region, 1970. USDA Forest Serv. Resource Bull. NC-14, 8 p. (NC)

118. Howard, James O. 1971. Forest products residues--Their volume, use, and value, Part 1, Volume of residues from logging. Forest Industries 98(12): 22-23. (PNW)

119. Howard, James O. 1971. Volume of logging residues in Oregon, Washington, and California--Initial results from a 1969-70 study. USDA Forest Serv. Res. Note PNW-163. (PNW)

120. Hutchins, C. C., Jr. 1971. Pulpwood prices in the Southeast, 1970. USDA Forest Serv. Res. Note SE-170, 4 p. (SE)

121. Kingsley, Neal P. 1971. Pulpwood in the Northeast: Past, Present, and Future. USDA Forest Serv. Resource Bull. NE-23, 21 p. (NE)

122. Sternitzke, H. S. 1971. Midsouth veneer log production. USDA Forest Serv. Resource Bull. SO-25, 9 p. (SO)

123. Wall, B. R. Forest products residues--Their volume, use and value, Part 4, Residues from secondary manufacturing. Forest Industries 98(12), 2 p. (PNW)

124. Wall, B.R. 1970. Washington timber harvest. USDA Forest Serv. Resource Bull. PNW-37, 2 p. (PNW)

125. Wall, B. R. 1970. Oregon timber harvest. USDA Forest Serv. Bull. PNW-38, 2 p. (PNW)

126. Welch, R. L. 1971. Veneer log production and receipts in the Southeast, 1969. USDA Forest Serv. Res. Note SE-158, 2 p. (SE)

Survey Techniques

127. Carmean, Willard H., and Alexander Vasilevsky. 1971. Site-index comparisons for tree species in northern Minnesota. USDA Forest Serv. Res. Pap. NC-65, 8 p. (NC)

128. Cost, N. D. 1971. Accuracy of standing-tree volume estimates based on McClure mirror caliper measurements. USDA Forest Serv. Res. Note SE-152, 4 p. (SE)

129. Dippold, Ronald M., and Wilbur A. Farr. 1971. Volume tables and equations for white spruce, balsam poplar, and paper birch of the Kuskowim River valley, Alaska. USDA Forest Serv. Res. Note PNW-147, 8 p. (PNW)

130. Farr, Wilbur A., and Vernon J. LaBau. 1971. Volume tables and equations for old-growth western redcedar and Alaska-cedar in southeast Alaska. USDA Forest Serv. Res. Note PNW-167, 18 p. (PNW)

131. Van Sickle, C. C. 1971. Functional appraisal of the forest resource. J. For. 69: 847-849. (SO)

FOREST RECREATION RESEARCH

Wilderness ecology and management

132. Craig, Alan J. 1972. Pollen influx to laminated sediments: A pollen diagram from northeastern Minnesota. Ecol. 53(1): 46-57. (NC) [1]

133. McCool, Stephen F., and Lawrence C. Merriam, Jr. 1971. Camper-outfitter interaction and the Boundary Waters Canoe Area, Superior National Forest, Minnesota. Univ. Minn., Minn. Forest. Res. Notes, No. 225, 4 p. (NC)

134. Merriam, L. C., Jr., Kent Goeckermann, J. A. Bloemendal, and T. M. Costello. 1971. A progress report on the condition of newly established campsites in the Boundary Waters Canoe Area. Univ. Minn., Minn. Forest. Res. Notes, No. 232, 4 p. (NC)

135. Ohmann, Lewis F., and Robert R. Ream. 1971. Wilderness ecology: Virgin plant communities of the Boundary Waters Canoe Area. USDA Forest Serv. Res. Pap. NC-63, 55 p. (NC)

136. Ream, Robert R., and Lewis F. Ohmann. 1971. Analysis of wilderness ecosystems. In Statist. Ecol. G. P. Patil, E. C. Pielou, and W. E. Waters (eds.). Penn State Press. Vol. 3: 123-131. (NC)

137. Stankey, G. H. 1971. Myths in wilderness decision-making. J. Soil and Water Conserv. 26: 183-188. (INT)

138. Stankey, George H. 1971. Wilderness: Carrying capacity and quality. Natur. Twenty-Two(3): 7-13. (INT)

[1] This publication begins the list for Forest Recreation Research.

Managing the visual environment

139. Kaplan, Stephen, and John S. Wendt. 1972. Preference and the visual environment: Complexity and some alternatives. In Environ. Design: Res. and Pract. Proc., Environ. Design Res. Assoc. Conf. Three, Los Angeles, Calif., 1972: 6-8-1 to 6-8-5. (NC)

140. Litton, R. Burton, Jr., and Kenji Shiozawa. 1971. Visual landscape units of the Lake Tahoe region, a guide to planning. (Prepared for Tahoe Reg. Plann. Agency and Forest Serv., USDA.) May 1971: 6-14. (PSW)

141. Meskimen, George. 1971. Managing forest landscapes: Is prescribed burning in the picture? In Prescribed Burning Symp. Proc., Charleston, S.C., April 14-16, 1971, p. 54-58. USDA Forest Serv. (SE)

142. Streeby, Larry L. 1970. Scenic management impact on other forest activities. J. Forest. 68: 430-432. (PSW)

Socioeconomic values of outdoor recreation

143. Burgess, Robert L., Roger N. Clark, and John C. Hendee. 1971. An experimental analysis of anti-litter procedures. J. Appl. Behav. Anal. 4(2): 71-75. (PNW)

144. Clark, Roger N., John C. Hendee, and Frederick L. Campbell. 1971. Depreciative behavior in forest campgrounds: An exploratory study. USDA Forest Serv. Res. Note PNW-161, 12 p. (PNW)

145. Clark, Roger N., John C. Hendee, and Frederick L. Campbell. 1971. Values, behavior and conflict in modern camping culture. J. Leisure Res. 3: 143-159. (PNW)

146. LaPage, Wilbur F., and Edward G. Fisher. 1971. Geographical variation in camper expenditures. USDA Forest Serv. Res. Note NE-139, 8 p. (NE)

147. Lime, David. 1971. Factors influencing campground use in the Superior National Forest of Minnesota. USDA Forest Serv. Res. Pap. NC-60, 18 p. (NC)

148. Moeller, George H. 1971. The landowner & the snowmobiler--problem or profit? USDA Forest Serv. Res. Pap. NE-206, 15 p. (NE)

149. Moeller, George H. 1971. Growth of the camping market in the Northeast. USDA Forest Serv. Res. Pap. NE-202, 21 p. (NE)

150. Whittaker, James C., and Herbert E. Echelberger. 1971. Land for recreation: A look at leasing in New York. USDA Forest Serv. Res. Pap. NE-182, 8 p. (NE)

Campsite design and management

151. Beardsley, Wendell G., and J. Alan Wagar. 1971. Vegetation management on a forested recreation site. J. Forest. 69: 728-731. (INT)

152. Cordell, Harold K., and George A. James. 1971. Supplementing vegetation on southern Appalachian recreation sites with small trees and shrubs. J. Soil and Water Conserv. 26: 235-238. (SE)

153. Echelberger, Herbert E. 1971. Vegetative changes at Adirondack campgrounds 1964 to 1969. USDA Forest Serv. Res. Note NE-142, 8 p. (NE)

Analyzing recreation resources and use

154. Elsner, Gary H. 1971. Using error measures to compare models on recreation use. J. Leisure Res. 3: 277-278. (PSW)

155. Elsner, Gary H. 1971. A regression method for estimating the level of use and market area of a proposed large ski resort. J. Leisure Res. 3: 160-167. (PSW)

156. Elsner, Gary H. 1971. Computing visible areas from proposed recreation developments. . . a case study. USDA Forest Serv. Res. Note PSW-246, 10 p. (PSW)

157. Elsner, Gary H. 1971. Campground users . . . a computerized method for summarizing where they come from and how long they stay. USDA Forest Serv. Res. Note PSW-258, 5 p. (PSW)

158. Hendee, John C., Richard P. Gale, and William R. Catton, Jr. 1971. A typology of outdoor recreation activity preferences. J. Environ. Educ. 3(1): 28-34. (PSW)

159. James, George A., and Hans T. Schreuder. 1971. Estimating recreation use on the San Gorgonio Wilderness. J. Forest. 69: 490-493. (SE)

160. James, George A., Nelson W. Taylor, and Melvin L. Hopkins. 1971. Estimating recreational use of a unique trout stream in the Coastal Plains of South Carolina. USDA Forest Serv. Res. Note SE-159, 7 p. (SE)

161. James, George A., H. Peter Wingle, and James D. Griggs. 1971. Estimating recreation use on large bodies of water. USDA Forest Serv. Res. Pap. SE-79, 7 p. (SE)

162. Lucas, Robert C., and Jerry L. Oltman. 1971. Survey sampling wilderness visitors. J. Leisure Res. 3: 28-43. (INT)

163. Lucas, Robert C., Hans T. Schreuder, and George A. James. 1971. Wilderness use estimation: A pilot test of sampling procedures on the Mission Mountains Primitive Area. USDA Forest Serv. Res. Pap. INT-109, 44 p. (INT)

164. Northeastern Forest Experiment Station. 1971. Recreation symposium proceedings. 211 p. USDA Forest Serv., Northeast. Forest Exp. Sta., Upper Darby, Pa. (NE)

165. Potter, Dale R., and J. Alan Wagar. 1971. Techniques for inventorying manmade impacts in roadway environments. USDA Forest Serv. Res. Pap. PNW-121, 12 p. (PNW)

166. Tyre, Gary L., and George A. James. 1971. Length and rate of individual participation in various activities on recreation sites and areas. USDA Forest Serv. Res. Note SE-161, 4 p. (SE)

RANGE MANAGEMENT RESEARCH

Evaluating range resources

167. Basile J. V. 1971. Site index for lodgepole pine--a poor indicator of site productivity for herbaceous plants. USDA Forest Serv. Res. Note INT-152. (INT)[1]

168. Driscoll, R. S. 1971. Color aerial photography--a new view for range management. USDA Forest Serv. Res. Pap. RM-67. (RM)

169. Driscoll, R. S., P. O. Currie, and M. J. Morris. 1972. Estimates of herbaceous standing crop by microdensitometry. In: Amer. Soc. Photograms. Proc., 38th Ann. Meet. 1972: 358-364. (RM)

Characteristics and forage values of range plants

170. Cable, D. R. 1971. Growth and development of Arizona cottontop. (Trichanchne californica [Benth] Chase). Bot. Gaz. 132: 119-145. (RM)

171. Murray, R. B. 1971. Grazing capacity, sheep gains: cheatgrass, bunchgrass ranges in southern Idaho. J. Range Manage. 24: 407-410. (INT)

172. Springfield, H. W. 1971. Winterfat seedlings emerge best from shallow seeding, moderately dry soils. J. Range Manage. 24: 395-397. (RM)

173. Springfield, H. W. 1972. Optimum temperatures for germination of winterfat. J. Range Manage. 25: 69-70.

Livestock and grazing management

174. Basile, J. V., and C. E. Jensen. 1971. Grazing potential on lodgepole pine clearcuts in Montana. USDA Forest Serv. Res. Pap. INT-98. (INT)

175. Pearson, H. A. 1971. Managing beef cow herds of forest ranges. Eleventh Annu. Livest. Prod. Day Proc. 1971: 14-20. La. State Univ. Press, Baton Rouge, La. (SO)

176. Pearson, H. A., L. B. Whitaker, and V. L. Duvall. 1971. Slash pine regeneration under regulated grazing. J. For. 69:744-746 (SO)

177. Pond, F. W., and D. R. Smith. 1971. Ecology and management of subalpine ranges on the Big Horn Mountains of Wyoming. Univ. of Wyoming Agr. Exp. Sta. Res. J. 53. (RM)

Range ecology

178. Thilenius, J. F. 1971. Vascular plants of the Black Hills of South Dakota and adjacent Wyoming. USDA Forest Serv. Res. Pap. RM-71. (RM)

Range improvements

179. Geist, J. M. 1971. Orchardgrass responses to fertilization of seven surface soils from the central Blue Mountains of Oregon. USDA Forest Serv. Res. Pap. PNW-122. (PNW)

[1]This publication begins the list for Range Management Research.

180. Hughes, R. H., G. W. Bengtson, and T. A. Harrington. 1971. Forage response to nitrogen and phosphorus fertilization in a 25-year-old plantation of slash pine. USDA Forest Serv. Res. Pap. SE-82. (SE)

181. Springfield, H. W. 1971. Selection and limitations of mulching materials for stabilizing critical areas. In Critical Area Stabilization Workshop. Proc. 128-161. N. Mexico Interagency Range Comm. Rep. 7A. (RM)

WATERSHED MANAGEMENT RESEARCH

Controlling soil erosion

182. Aldon, Earl F., and H. G. Brown III. 1971. Geological soil groupings for the pinyon-juniper type on National Forests in New Mexico. U.S. Forest Serv. Res. Note RM-197, 4 p. (RM) [1]

183. Brown, Ray W., R. H. Ruf, Jr., and E. E. Farmer. 1971. Stability of Ceanothus prostratus Benth for the revegetation of harsh sites. USDA Forest Serv. Res. Note INT-144, 12 p. (INT)

184. Curtis, Willie R. 1971. Terraces reduce runoff and erosion on surface-mine benches. J. Soil and Water Conserv. 26(5): 198-199. (NE)

185. Farmer, Eugene E., and Bruce P. Van Haveren. 1971. Soil erosion by overland flow and raindrop splash on three mountain soils. USDA Forest Serv. Res. Pap. INT-100, 14 p. (INT)

186. Heede, Burchard H. 1971. Characteristics and processes of soil piping in gullies. USDA Forest Serv. Res. Pap. RM-68, 15 p. (RM)

187. Ketchledge, E. H., and R. E. Leonard. 1971. Progress report: High Peak erosion studies. Adirondack Peaks 8(2): 8-9. (NE)

188. Klock, G. O., J. M. Geist, and A. R. Tiedemann. 1971. Erosion control fertilization--from pot study to field testing. Sulphur Institute J. 7: 7-10. (PNW)

189. Knipe, O. D. 1971. Light delays germination of alkali sacaton. J. Range Manage. 24(2): 152-154. (RM)

190. Knipe, O. D. 1971. Effect of different osmotica on germination of alkali sacaton (Sporobolus airoides Torr.) at various moisture stresses. Bot. Gaz. 132(2): 109-112. (RM)

191. Meeuwig, Richard O. 1971. Soil stability on high-elevation rangeland in the Intermountain area. USDA Forest Serv. Res. Pap. INT-94, 10 p. (INT)

192. Megahan, W. F., and W. J. Kidd. 1972. Effects of logging and logging roads on erosion and sediment deposition from steep terrain. J. Forest. 70(3): 136-141. (INT)

193. Paeth, R. C., M. F. Harward, E. G. Knox, and C. T. Dyrness. 1971. Factors affecting mass movement of four soils in the western Cascades of Oregon. SSSA Proc. 35(6): 943-947. (PNW)

194. Rice, R. M., and G. T. Foggin, III. 1971. Effect of high intensity storms on soil slippage on mountainous watersheds in southern California. Water Resour. Res. 7(6): 1485-1496. (PSW)

Utilizing solid wastes

195. Bollen, W. B. 1971. Salty bark as a soil amendment. USDA Forest Serv. Res. Pap. PNW-128, 16 p. (PNW)

[1] This publication begins the list for Watershed Management Research.

Chemicals in the forest environment

196. Bollen, W. B., and C. M. Tu. 1971. Influence of endrin on soil microbial populations and their activity. USDA Forest Serv. Res. Pap. PNW-114, 4 p. (PNW)

197. Clayton, James L. 1972. Salt spray and mineral cycling in two California coastal ecosystems. Ecology 53(1): 74-81. (INT)

198. Moore, Duane G. 1971. Principles of monitoring. Proc. Short Course for Pesticide Applicators. OSU, J. Capizzi and J. Witt, eds., p. 155-168. (PNW)

199. Montgomery, Marvin L., and L. A. Norris. 1970. Eine vorlaufige Bewertung der Gefahren, die mit der Anwendung von 2, 4, 5-T im Wald verbunden sind. (A preliminary evaluation of the hazards of 2, 4, 5-T in the forest environment.) Die Bodenkultur 21(4): 425-431. (PNW)

200. Newton, Michael, and L. A. Norris. 1970. Herbicide usage. Science 168: 1606-1607. (PNW)

201. Norris, Logan A. 1971. Studies of the safety of organic arsenical herbicides as precommercial thinning agents: A progress report. In: Precommercial Thinning of Coastal and Intermountain Forests in the Pacific Northwest. Washington State University, Pullman, p. 63-74, Proc. of Symp. February 3-4, 1971. (PNW)

202. Norris, Logan A. 1971. Chemical brush control--assessing the hazard. J. Forest. 69: 715-720. (PNW)

203. Norris, Logan A. 1971. The behavior of chemicals in the forest. Proc. 1971 Short Course for Pesticide Applicators. OSU, J. Capizzi and J. Witt, eds., p. 90-106. (PNW)

204. Norris, Logan A., and D. G. Moore. 1971. The entry and fate of chemicals in streams. Proc. of Symp. on Forest Land Uses and Stream Environment, October 19-21, 1970, Oregon State University, p. 138-158. (PNW)

205. Sears, Howard S., and W. R. Meehan. 1971. Short-term effects of 2, 4-D on aquatic organisms in the Nakwasina River watershed, southeastern Alaska. Pesticides Monitoring J. 5(2): 213-217. (PNW)

206. Tarrant, Robert F. 1971. Persistence of some chemicals in Pacific Northwest forests. Proc. 1971 Short Course for Pesticide Applicators. OSU, J. Capizzi and J. Witt, eds., p. 133-141. (PNW)

207. Tarrant, Robert F., and Jack Allard. 1972. Arsenic levels in urine of forest workers applying silvicides. Archives of Environ. Health 24: 277-280. (PNW)

Noise abatement

208. Leonard, R. E. 1971. Effect of trees and forests in noise abatement. Trees and Forests in An Urbanizing Environment, Univ. of Mass. Symp. Proc., p. 35-38. (NE)

209. Leonard, R. E., and L. P. Herrington. 1971. Noise abatement in a pine plantation. USDA Forest Serv. Res. Note NE-140, 6 p. (NE)

Improving water yields

210. Aubertin, G. M. 1971. Nature and extent of macropores in forest soils and their influence on subsurface water movement. USDA Forest Serv. Res. Pap. NE-192, 33 p. (NE)

211. Bethlahmy, Nedavia. 1972. Comments on "Effects of forest clearfelling on the storm hydrograph" by John D. Hewlett and J. D. Helvey. Water Resour. Res. 8(1): 166-170. (INT)

212. Bethlahmy, Nedavia. 1971. Maximum peak flows for selected return periods for watersheds west of the Continental Divide in Idaho and Montana. USDA Forest Serv. Res. Pap. INT-113, 12 p. (INT)

213. Berndt, H. W. 1971. Early effects of forest fire on streamflow characteristics. USDA Forest Serv. Res. Note PNW-148, 9 p. (PNW)

214. Boersma, L. L., D. Kirkham, D. Norum, and others. 1971. Soil moisture. EOS, Trans. Amer. Geophys. Union, 52(6): IUGG 279-285. (PSW)

215. Burroughs, Edward R., Michael A. Marsden, and Harold F. Haupt. 1972. Volume of snowmelt intercepted by logging roads. J. of Irrig. and Drainage Div. Proc. of ASCE-IR1: 1-12. (INT)

216. Campbell, Ralph E. 1971. Evaporation from bare soil as affected by texture and temperature. USDA Forest Serv. Res. Note RM-190, 7 p. (RM)

217. Doty, Robert D. 1971. Contour trenching effects on streamflow from a Utah watershed. USDA Forest Serv. Res. Pap. INT-95, 19 p. (INT)

218. Farmer, Eugene E., and Joel E. Fletcher. 1971. Precipitation characteristics of summer storms at high-elevation stations in Utah. USDA Forest Serv. Res. Pap. INT-110, 24 p. (INT)

219. Farmer, Eugene E., and Joel E. Fletcher. 1972. Rainfall intensity-duration-frequency relations for the Wasatch Mountains of northern Utah. Water Resour. Res. 8(1): 266-271. (INT)

220. Federer, C. A., and R. E. Leonard. 1971. Snowmelt in hardwood forests. 1971 Eastern Snow Conf. Proc., p. 95-109. (NE)

221. Foggin, G. Thomas, III, and Leonard F. DeBano. 1971. Some geographic implications of water-repellent soils. The Professional Geographer, Vol. XXIII (4): 347-350. (PSW)

222. Fowler, W. B., and H. W. Berndt. 1971. Efficiency of foliage in horizontal interception. Proc. of the Western Snow Conf., 39th Annual Meeting, Billings, Montana, p. 27-33. (PNW)

223. Haeffner, Arden D. 1971. Daily temperatures and precipitation for subalpine forest, central Colorado. USDA Forest Serv. Res. Pap. RM-80, 48 p. (RM)

224. Haupt, Harold F. 1972. The release of water from forest snowpacks during winter. USDA Forest Serv. Res. Pap. INT-114, 17 p. (INT)

225. Hibbert, Alden R., and Wilson B. Casner. 1971. Reducing excess readouts from digital streamflow recorders. Water Resour. Res. 7(2): 415-418. (RM)

226. Ingebo, Paul A. 1971. Suppression of channel-side chaparral cover increases streamflow. J. Soil Water Conserv. 26(2): 79-81. (RM)

227. Ingebo, Paul A., Wilson B. Casner, and Gary L. Godsey. 1971. A computer program for computing streamflow volumes. USDA Forest Serv. Res. Note RM-203, p. 1-8. (RM)

228. Johnston, Robert S. 1971. Rainfall interception in a dense Utah aspen clone. USDA Forest Serv. Res. Note INT-143, 4 p. (INT)

229. Klock, G. O. 1972. Snowmelt temperature influence on infiltration and soil water retention. J. Soil and Water Conserv. 27: 12-14. (PNW)

230. Kochenderfer, J. N. 1971. Soil moisture under white pine and mixed hardwood forest. Trans. Amer. Geophys. Union 52(4): 201. (NE)

231. Lull, Howard W. 1971. Effects of trees and forests on water relations. Trees and Forests in an Urbanizing Environment, Univ. Mass. Symp. Proc., p. 65-69. (NE)

232. Meeuwig, Richard O. 1971. Infiltration and water repellency in granitic soils. USDA Forest Serv. Res. Pap. INT-111, 20 p. (INT)

233. Orr, Howard K. 1972. Throughfall and stemflow relationships in second-growth ponderosa pine in the Black Hills. USDA Forest Serv. Res. Note RM-210. (RM)

234. Patric, J. H., and K. E. Reinhart. 1971. Hydrologic effects of deforesting two mountain watersheds in West Virginia. Water Resour. Res. 7(5): 1182-1188. (NE)

235. Pierce, Robert S. 1971. Clearcutting and stream water. N. H. Forest Notes, Spring 1971. (NE)

236. Rogerson, T. L. 1971. Hydrologic characteristics of small headwater catchments in the Ouachita Mountains. USDA Forest Serv. Res. Note SO-117, 5 p. (SO)

237. Rothacher, Jack. 1971. Regimes of streamflow and their modification by logging. In Forest Land Uses and Stream Environ. Symp. Proc., Oregon State Univ. Corvallis, Oreg. p. 40-54. (PNW)

238. Sartz, Richard S. 1972. Anomalies and sampling variation in forest soil water measurement by the neutron method. Soil Sci. Soc. Amer. Proc., 36: 148-153. (NC)

239. Sartz, Richard S. 1972. Effect of topography on microclimate in southwestern Wisconsin. USDA Forest Serv. Res. Pap. NC-74, 6 p. (NC)

240. Smith, James L. 1971. Snow research in the Sierra Nevada, California. USDA Forest Serv. Unnumbered publication, 7 p. (PSW)

241. Sommerfeld, R. A. 1971. The relationship between density and tensile strength in snow. J. Glaciol. 10(60): 357-362. (RM)

242. Troendle, C. A., and J. W. Homeyer. 1971. Stormflow related to measured physical parameters on small forested watersheds in West Virginia. Trans. Amer. Geophys. Union 52(4): 204. (NE)

243. Urie, D. H. 1971. Estimated groundwater yield following strip-cutting in pine plantations. Water Resour. Res. 7(6): 1497-1510. (NC)

244. Urie, D. H. 1971. Lake Michigan snow squalls increase annual precipitation in the Udell Hills. USDA Forest Serv. Res. Note NC-120, 4 p. (NC)

Managing watersheds

245. Aldon, Earl F., and George Garcia. 1971. Stocking rangelands on the Rio Puerco in New Mexico. J. Range Manage. 24(5): 344-345. (RM)

246. Aldon, Earl F., and H. W. Springfield. 1972. Southwestern pinyon-juniper ecosystems: a bibliography. USDA Forest Serv. Unnumbered publication, 66 p. (RM)

247. Anderson, Henry W. 1972. International Symposium on Mathematical Models in Hydrology, Warsaw, Poland, July 26-31, 1971, EOS, Trans. Amer. Union 53(1): 25-26. (PSW)

248. Bergen, James D. 1971. Topographic effects apparent in nocturnal temperature profiles in a conifer canopy. Agric. Meteorol. 9: 39-50. (RM)

249. Bergen, James D. 1971. Vertical profiles through a conifer stand. Forest Sci. 17(3): 314-321. (RM)

250. Bergen, James D. 1971. The relation of snow transparency to density and air permeability in a natural snow cover. J. Geophys. Res. 76(30): 7385-7388. (RM)

251. Clary, Warren P. 1971. Effects of Utah juniper removal on herbage yields from Springerville soils. J. Range Manage. 24(5): 373-378. (RM)

252. Clary, Warren P., and Frederic R. Larson. 1971. Elk and deer use are related to food sources in Arizona ponderosa pine. USDA Forest Serv. Res. Note RM-202, 4 p. (RM)

253. Corbett, E. S. 1971. Status of management on forested municipal watersheds in the Northeast. Pa. Forests 62(4): 100-101. (NE)

254. Federer, C. A. 1971. Effects of trees in modifying urban microclimate. In Symp. on Trees and Forests in an Urbanizing Environment, Univ. Mass. Coop. Ext. Serv., p. 23-28. (NE)

255. Griffing, C. G., and W. W. Elam. 1971. Height growth patterns of loblolly pine saplings. Forest Sci. 17: 52-54. (SO)

256. Klock, G. O. 1971. Streamflow nitrogen loss following forest erosion control fertilization. USDA Forest Serv. Res. Note PNW-169, 9 p. (PNW)

257. Leaf, A. L., and R. E. Leonard. 1971. A rational approach to forest treatments. South. Lumberman, December 1971: 169. (NE)

258. Leaf, Charles F., and Arden D. Haeffner. 1971. A model for updating streamflow forecasts based on areal snow cover and a precipitation index. West. Snow Conf. Proc. 39: 9-16. Billings, Mont., April 1971. (RM)

259. Leaf, Charles F., and Jacob L. Kovner. 1971. Guidelines for sampling area-mean water equivalent in forested watersheds. In Hydrometeorological networks in Wyoming--their design and use. Hydrol. Seminar, Laramie, Wyoming, May 1971, Proc. p. 159-167. Water Resour. Res. Inst. Rep., Wyoming Univ., Laramie. (RM)

260. Leonard, R. E., A. L. Leaf, J. V. Berglund, and P. J. Craul. 1971. Annual soil moisture-temperature patterns as influenced by irrigation. Soil Sci. 3(4): 220-227. (NE)

261. Miller, Robert L. 1971. Clearing an alligator juniper watershed with saws and chemicals: A cost analysis. USDA Forest Serv. Res. Note RM-183, 8 p. (RM)

262. Muller, Robert A. 1971. Transmission components of solar radiation in pine stands in relation to climatic and stand variables. USDA Forest Serv. Res. Pap. PSW-71, 13 p. (PSW)

263. Pase, Charles P., and A. W. Lindenmuth, Jr. 1971. Effects of prescribed fire on vegetation and sediment in oak-mountain-mahogany chaparral. J. Forest. 69(11): 800-804. (RM)

264. Pase, Charles P. 1971. Effect of a February burn on Lehmann lovegrass. J. Range Manage. 24(6): 454-456. (RM)

265. Sartz, Richard S. 1971. Storm flow from dual-use watersheds in southwestern Wisconsin. USDA Forest Serv. Res. Pap. NC-69, 7 p. (NC)

266. Smith, F. W., R. A. Sommerfeld, and R. O. Bailey. 1971. Finite-element stress analysis of avalanche snowpacks. J. Glaciol. 10(60): 401-406. (RM)

267. Tabler, Ronald D. 1971. Design of a watershed snow fence system, and first-year snow accumulation. 39th Western Snow Conf. Proc., p. 50-55, April 20-22, Billings, Mont. (RM)

268. Tiedemann, A. R., and T. D. Anderson. 1971. Rapid analysis of total sulphur in soils and plant material. Plant and Soil 35: 197-200. (PNW)

269. Tiedemann, A. R., and H. W. Berndt. 1972. Vegetation and soils of a 30-year deer and elk exclosure in central Washington. Northwest Sci. 46: 59-66. (PNW)

Watershed rehabilitation and damage prevention

270. Anderson, Henry W. 1971. Relative contribution of sediment from source areas, and transport processes. In Proc. Symp. on Forest Land Use and Stream Environment, Oregon State Univ., Corvallis, October 19-21, 1970, p. 55-63. (PSW)

271. Curtis, Willie R. 1971. Strip-mining, erosion, and sedimentation. Trans. Amer. Soc. Agri. Engr. 14(13): 434-436. (NE)

272. Dickerson, B. P. 1971. Texas "Lost Pines" not superior on dry sites in northern Mississippi. USDA Forest Serv. Res. Note SO-119, 4 p. (SO)

273. Duffy, P. D. 1971. Loblolly pine seedlings respond to foliar nitrogen fertilization. USDA Forest Serv. Res. Note SO-122, 4 p. (SO)

274. Frolich, Matthew, R. H. Ruf, Jr., and P. E. Packer. 1971. Germination inhibition in seed of Ceanothus prostratus Benth. USDA Forest Serv. Res. Note INT-149, 6 p. (INT)

275. Klock, G. O., and W. A. Hampton. 1972. Skiing--and on a grass base. Washington Farmer-Stockman 97(2): 34. (PNW)

276. Knighton, M. Dean. 1972. Effects of ground preparation on planted red pine in Southwestern Wisconsin. USDA Forest Serv. Res. Note NC-134, 2 p. (NC)

277. Leaf, A. L., R. E. Leonard, and J. V. Berglund. 1971. Root distribution of a plantation-grown red pine in an outwash soil. Ecol. 52(1): 153-158. (NE)

278. Lusby, Gregg C., Vincent H. Reid, and O. D. Knipe. 1971. Effects of grazing on the hydrology and biology of the Badger Wash Basin in Western Colorado, 1953-1966. U.S. Dept. of the Interior, Geological Survey Water-Supply Paper 1532-D, 90 p. (RM)

279. McClurkin, D. C. 1971. Containerized pines for eroded watersheds. J. Soil and Water Conserv. 26(1): 25-26. (SO)

280. Schier, G. A., and R. S. Johnston. 1971. Clonal variation in total nonstructural carbohydrates of trembling aspen roots in three Utah areas. Canadian J. Forest Res. (4): 252-255. (INT)

281. Swanston, D. N. 1971. Principal mass movement processes influenced by logging, roadbuilding, and fire. In Forest Land Uses and Stream Environment Symp. Proc., Oregon State Univ., Corvallis, p. 29-39. (PNW)

282. Van Lear, David H. 1971. Effects of spoil texture on growth of K-31 tall fescue. USDA Forest Serv. Res. Note NE-141, 7 p. (NE)

283. Wood, Hulton B. 1971. Land use effects on the hydrologic characteristics of some Hawaiian soils. J. of Soil and Water Conserv. 26(4): 158-160. (PSW)

Water quality

284. Aubertin, G. M., and J. H. Patric. 1972. Quality water from clearcut forest land? The Northern Logger and Timber Processor, March 1972, p. 14, 15, 22, 23. (NE)

285. Brown, George W., Gerald W. Swank, and Jack Rothacher. 1971. Water temperature in the Steamboat drainage. USDA Forest Serv. Res. Pap. PNW-119, 17 p. (PNW)

286. Burns, James W. 1972. Some effects of logging and associated road construction on Northern California streams. Amer. Fisheries Soc. Trans. 101(1): 1-17. (PSW)

287. Fredriksen, R. L. 1971. Comparative chemical water quality--natural and disturbed streams following logging and slash burning. In Forest Land Uses and Stream Environment Symp. Proc., Oregon State Univ., Corvallis, Oregon, p. 125-135. (PNW)

288. Hansen, Edward A. 1971. Sediment in a Michigan trout stream; its source, movement and some effects on fish habitat. USDA Forest Serv. Res. Pap. NC-59, 14 p. (NC)

289. Leaf, Charles F. 1971. Sediment yields from central Colorado snow zone. Amer. Soc. Civ. Engr. Proc., J. Hydraul. Div. 97(HY2): 350-351. (Closure) (RM)

290. Meehan, William R. 1971. Effects of gravel cleaning on bottom organisms in three southeast Alaska streams. Progressive Fish-Culturist 33(2): 107-111. (PNW)

291. Swift, L. W., Jr., and J. B. Messer. 1971. Forest cuttings raise temperatures of small streams in the southern Appalachians. J. Soil and Water Conserv. 26(3): 111-116. (SE)

292. Urie, D. H. 1971. Opportunities and plans for sewage renovation on forests and wildlands in Michigan. Michigan Academician, Vol. IV(1): 115-124. (NC)

Measuring environmental parameters

293. Bergen, James D. 1971. An inexpensive heated thermistor anemometer. Agr. Meteorol. 8: 395-405. (RM)

294. Brown, James M. 1971. Economical conversion of a miniature net radiometer to an all-wave hemispheric radiometer. USDA Forest Serv. Res. Note NC-123, 2 p. (NC)

295. Brown, Ray W., and M. L. H. Caldwell. 1971. Construction and operation of a compact fine-wire psychrometer. USDA Forest Serv. Res. Note INT-142, 6 p. (INT)

296. Curtis, Willie R., and William D. Cole. 1972. Microtopographic profile gage. J. Amer. Soc. Agri. Engr. 53(1): 17. (NE)

297. Federer, C. A. 1971. Solar radiation absorption by leafless hardwood forests. Agri. Meteorol. 9: 3-20. (NE)

298. Fowler, W. B. 1971. Radioisotopic monitor for rime accumulation. Isotopes and Radiation Tech. 9(2): 182. (PNW)

299. Judson, Arthur. 1971. An infrared deicing unit for cup anemometers. USDA Forest Serv. Res. Note RM-187, 4 p. (RM)

300. Larson, Frederic R., Karl E. Moessner, and Peter F. Ffolliott. 1971. A comparison of aerial photo and ground measurements of ponderosa pine stands. USDA Forest Serv. Res. Note RM-192, 4 p. (RM)

301. McClurkin, D. C., I. T. McClurkin, and T. J. Culpepper. 1971. Cyto-chemical and tissue homogenate analysis of adenosine triphosphatase in root tips of Texas "Lost Pines." Forest Sci. 17: 446-451. (SO)

302. Richardson, Bland Z., and Edward R. Burroughs, Jr. 1971. A pump manometer for ground water studies. USDA Forest Serv. Res. Note INT-137, 11 p. (INT)

303. Schmidt, R. A., Jr. 1971. Processing size, frequency, and speed data from snow particle counters. USDA Forest Serv. Res. Note RM-196, 4 p. (RM)

304. Schmidt, R. A., Jr., and E. W. Holub. 1971. Calibrating the snow particle counter for particle size and speed. USDA Forest Serv. Res. Note RM-189, 8 p. (RM)

305. Smith, James L., Howard G. Halverson, and Ronald A. Jones. The profiling radioactive snow gate. In Trans. Isotopic Snow Gage Information Meeting. Sun Valley, Idaho, p. 17-35. Idaho Nuclear Energy Commission, Idaho Falls, Idaho. (PSW)

306. Tabler, Ronald D., and Robert L. Jairell. 1971. A recording gage for blowing snow. USDA Forest Serv. Res. Note RM-193, 7 p. (RM)

307. Van Haveren, Bruce P., and Eugene E. Farmer. 1971. An insulated evaporimeter. Water Resour. Bull. 7(6): 1250-1252. (INT)

308. Wiebe, Herman H., G. S. Campbell, W. H. Gardner, and others. 1971. Measurement of plant and soil water status. Utah Agr. Exp. Sta. Bull. 484, 71 p. (INT)

WILDLIFE HABITAT RESEARCH

Evaluating and improving wildlife habitat

309. Brander, R. B. 1971. Longevity of wild porcupines. J. Mammalogy 52: 835. (NC)[1]

310. Edgerton, P. J., and J. G. Smith. 1971. Seasonal forage use by deer and elk on the Starkey Experimental Forest and Range, Oregon. USDA Forest Serv. Res. Pap. PNW-112. (PNW)

311. Halls, L. K., and J. J. Stransky. 1971. Atlas of southern forest game. USDA Forest Serv. South. Forest Exp. Sta. (SO)

312. Hanks, D. L., J. R. Brunner, D. R. Christensen, and A. P. Plummer. 1971. Paper chromatography for determining palatability differences in various strains of big sagebrush. USDA Forest Serv. Res. Pap. INT-101. (INT)

313. Harlow, R. F., and R. G. Hooper, 1971. Forages eaten by deer in the Southeast. Southeast. Assoc. Game and Fish Comm. Annu. Conf. Proc. 13. (SE)

314. Reichert, D. W. 1972. Rearing and training deer for food habits studies. USDA Forest Serv. Res. Note RM-208. (RM)

315. Ward, A. L. 1971. In vitro digestibility of elk winter forage in southern Wyoming. J. Wildl. Manage. 35: 681-688. (RM)

Integrating wildlife and other land uses

316. Crawford, H. S. Jr., and W. M. Harrison. 1971. Wildlife food on three Ozark hardwood sites after regeneration cutting. J. Wildl. Manage. 35: 533-537. (NC)

317. Crawford, H. S., Jr. 1971. Wildlife habitat changes after intermediate cutting for even-aged oak management. J. Wild. Manage. 35: 275-286. (SE)

318. Edgerton, P. J. 1971. The effect of cattle and big game grazing on a ponderosa pine plantation. USDA Forest Serv. Res. Note PNW-172. (PNW)

319. Harshbarger, T. J., and J. L. Buckner. 1971. Quail foods in Georgia flatwoods. Ga. Forest Res. Counc. Res. Pap. 68. (SE)

320. Pack, J. C., H. R. Sanderson, and R. W. Donohoe. 1971. Comparison of gray squirrel census techniques. Trans. Northeast Sect. The Wildl. Soc., 28th Conf., Portland, Maine, 145-158. (NE)

---

[1] This publication begins the list for Wildlife Habitat Research.

Fire prevention, hazard reduction, and prescribed burning

321. Bentley, Jay R., David A. Blakeman, and Stanley B. Carpenter. 1971. Recovery of young ponderosa pines damaged by herbicide spraying. USDA Forest Serv. Res. Note PSW-252, 7 p. (PSW) [1]

322. Bentley, Jay R., Stanley B. Carpenter, and David A. Blakeman. 1971. Early brush control promotes growth of ponderosa pine planted on bulldozed site. USDA Forest Serv. Res. Note PSW-238, 5 p. (PSW)

323. Bentley, Jay R., C. Eugene Conrad, and Harry E. Schimke. 1971. Burning trials in shrubby vegetation desiccated with herbicides. USDA Forest Serv. Res. Note PSW-241, 9 p. (PSW)

324. Berg, Arthur R. 1972. Grass reproduction. In Biology and Utilization of Grasses. Academic Press, V. B. Youngner and C. M. McKell, eds. Chap. 24, p 334-347. (PSW)

325. Christiansen, J. R., and W. S. Folkman. 1971. Characteristics of people who start fires... some preliminary findings. USDA Forest Serv. Res. Note PSW-251, 5 p. (PSW)

326. Dickerson, B. E. 1971. Communicating fire prevention messages effectively. J. Forest. 69: 812-813. (SO)

327. Dieterich, John H. 1971. Prescribed burning and air quality. In Southern Pine Management-Today and Tomorrow. Proc. 20th Annual For. Symp., La. State Univ., Baton Rouge, La., p 115-129. (SE)

328. Dieterich, John H. 1971. Air-quality aspects of prescribed burning. In Proc. Prescribed Burning Symp., Charleston, S.C., p. 139-151. (SE)

329. Dieterich, John H. 1971. Prescribed fire effects on air quality. In Proc. 68th Ann. Conv. Assn. Southern Agr. Workers' Meet., Jacksonville, Fla., 5 p. (SE)

330. Dixon, M. J. 1971. Needed: new emphasis on fire prevention. Forest Farmer 30(10): 8, 9, 18. (SO)

331. Evans, Lance S., and Arthur R. Berg. 1971. Leaf and apical growth characteristics in Triticum. Amer. Jour. Bot. 58(6): 540-543. (PSW)

332. Evans, Lance S., and Arthur R. Berg. 1972. Quantitative histo-chemistry of the shoot apex of Triticum. Can. Jour. Bot. 50(1): 241-244. (PSW)

333. Green, Lisle R., and Harry E. Schimke. 1971. Guides for fuelbreaks in the Sierra Nevada mixed-conifer type. USDA Forest Serv. PSW Unnumbered Pap., 14 p. (PSW)

334. Nord, Eamor C., and Louis E. Gunter. 1971. Gibberellic acid breaks dormancy and hastens germination of creeping sage. USDA Forest Serv. Res. Note PSW-259, 5 p. (PSW)

335. Nord, Eamor C., Patrick F. Hartless, and W. Dennis Nettleton. 1971. Effects of several factors on saltbush establishment in California. J. Range Manage. 24(3): 216-223. (PSW)

336. Pase, C. P., and A. W. Lindenmuth, Jr. 1971. Effects of prescribed fire on vegetation and sediment in oak-mountain mahogany chaparral. J. Forest. 69(11): 800-805. (RM)

---

[1] This publication begins the list for Forest Fire and Atmospheric Sciences Research.

337. Pharo, James A. 1971. Air quality study. In Proc. Fire Research Workshop, Macon, Ga., and Knoxville, Tenn., p. 49-57. (SE)

338. Plumb, T. R. 1971. Broadcast applications of herbicides to control scrub oak regrowth. USDA Forest Serv. Res. Note PSW-261, 4 p. (PSW)

339. Probasco, George E., and John S. Crosby. 1972. Little blue stem (Andropogon scoparius Michx.) mortality resulting from fire and defoliation (Abstr.). J. Range Manage. Abstr. of Pap.: 25. (NC)

340. Sackett, Stephen S. 1971. Prescribed fire research at the Southern Forest Fire Laboratory. In Proc. Fire Research Workshop, Macon, Ga., and Knoxville, Tenn., p. 27-29. (SE)

341. Sackett, Stephen S., and Darold E. Ward. 1972. A mobile heat applicator for simulating prescribed fire intensities. USDA Forest Serv., Southeast. Forest Exp. Sta. Res. Note SE-172, 8 p. (SE)

342. Salminen, Seppo O., Athan A. Gagianas, and Arthur R. Berg. 1972. The effect of NAA (1-Napthaleneacetic Acid) and Morphactin (Methyl 2-Choloro-9-hydroxyfluorene-9-carboxylate) on RNA and protein synthesis in senescing bean endocarp. Plant Physiol. 26: 186-190. (PSW)

343. Sando, Rodney W. 1971. A summary of prescribed burning done in the Lake States during 1970. USDA For. Serv. Res. Note NC-215, 2 p. (NC)

344. Ward, D. E., and R. C. Lamb. 1971. Prescribed burning and air quality--current research in the South. In Proc. Tenth Ann. Tall Timbers Fire Ecol. Conf., New Brunswick, Con., p. 129-140. (SE)

Fire management methods and systems

345. Aldrich, D., and R. W. Mutch. 1972. Wilderness fires allowed to burn more naturally. USDA Forest Service Fire Control Notes 33(1): 3-5. (INT)

346. Anon. 1971. Evaluation of forest fire retardants. USDA Forest Serv., Wash., D.C., 20 p. (INT)

347. Barrows, J. S. 1971. New technology and fire management. In Proc. Western Forestry and Conservation Association Annual Meeting, Portland, Oreg. (In press.) (WO)

348. Barrows, J. S. 1971. Fire-fighting chemicals. In Proc. Employment of Air Operations in the Fire Services, Argonne, Ill., p. 105-112. (WO)

349. Deeming, John E., and James W. Lancaster. 1971. Background, philosophy, implementation--National Fire Danger Rating System. USDA Forest Serv., Fire Control Notes 32(2): 4-8. (RM)

350. Deeming, John E., James W. Lancaster, Michael A. Fosberg, R. William Furman, and Mark J. Schroeder. 1972. National Fire Danger Rating System. USDA Forest Serv. Res. Pap. RM-84, 165 p. (RM)

351. Fosberg, Michael A. 1971. Moisture content calculations for the 100-hour timelag fuel in fire-danger rating. USDA Forest Serv. Res. Note RM-199, 7 p. (RM)

352. Fosberg, Michael A., and Mark J. Schroeder. 1971. Fine herbaceous fuels in fire-danger rating. USDA Forest Serv. Res. Note RM-185), 7 p. (RM)

353. George, Charles W. 1971. Retardant salt concentration measured in the field. USDA Forest Serv. Res. Note INT-138, 14 p. (INT)

354. George, Charles W. 1971. Liquids fight forest fires. Fert. Solutions 15(6): 10-11, 15, 18, 21. (INT)

355. Hartong, Allan L. 1971. An analysis of retardant use. USDA Forest Serv. Res. Pap. INT-103, 40 p. (INT)

356. Johansen, R. W. 1971. Chemicals, strategy, tactics, and other considerations in forest fire suppression. In Proc. Fire Research Workshop, Macon, Ga., and Knoxville, Tenn., p. 8-10. (SE)

357. Noste, Nonan V. 1971. A relationship between National Fire Danger Rating System spread index and time-of-day in interior Alaska. In Proc., Fire in the Northern Environment--a Symposium, p. 121-129. Pac. NW For. & Range Exp. Sta. (PNW)

358. Philpot, C. W., C. W. George, A. D. Blakely, G. M. Johnson, and W. H. Wallace, Jr. 1972. The effect of two flame retardants on particulate and residue production. USDA Forest Serv. Res. Pap. INT-117, 14 p. (INT)

359. Ryan, P. W. 1971. Forest fires and fire danger in Georgia: a ten-year summary 1959-1968. Ga. Forest Res. Coun. Rep. 27, 28 p. (SE)

360. Storey, Theodore G. 1972. FOCUS: a computer simulation model for fire control planning. Fire Tech. (In press.) (PSW)

Forest fire science

361. Barney, Richard J. 1971. Wildfires in Alaska--some historical and projected effects and aspects. In Proc., Fire in the Northern Environment--a Symposium, p. 51-59. Pac. NW For. and Range Exp. Sta. (PNW)

362. Barney, Richard J. 1971. Selected 1966-69 interior Alaska wildfire statistics with long-term comparisons. USDA Forest Serv. Res. Note PNW-154, 13 p. (PNW)

363. Barney, Richard J., and Thomas C. Van Wickle. 1971. A "battery saver" for event recorders. USDA. Forest Serv. Res. Note PNW-168, 6 p. (PNW)

364. Beaufait, William R. 1971. Fire and smoke in Montana forests. Mont. Forest and Conserv. Exp. Sta., Univ. of Mont., 23 p. (INT)

365. Blackmarr, W. H. 1971. Equilibrium moisture content of common fine fuels found in southeastern forests. USDA Forest Serv. Res. Pap. SE-74, 8 p. (SE)

366. Britton, Carlton M., Clive M. Countryman, and Henry A. Wright, 1971. Equilibrium moisture content of Tobosa grass. In Noxious Brush and Weed Control Highlights, Texas Tech. Univ., Lubbock, Texas, p. 18. (PSW)

367. Broido, A., and M. Weinstein. 1972. Low temperature isothermal pyrolysis of cellulose. In Proc. 3rd Int. Conf. on Thermal Analysis, Davos, Switzerland, p. 285. (PSW)

368. Brown, J. K. 1971. A planar intersect method for supplying fuel volume and surface area. Forest Sci. 16(1): 96-102. (INT)

369. Brown, J. K. 1972. Field test of a rate-of-fire spread model in slash fuels. USDA Forest Serv. Res. Pap. INT-116, 24 p. (INT)

370. Countryman, Clive M. 1971. Carbon monoxide; a firefighting hazard. USDA Forest Serv. PSW Unnumbered Pap., 6 p. (PSW)

371. Dell, John D., and Franklin R. Ward. 171. Logging residues on Douglas-fir region clearcuts--weights and volumes. USDA Forest Serv. Res. Pap. PNW-115, 10 p. (PNW)

372. Fosberg, Michael A. 1971. Climatological influences on moisture characteristics of dead fuel: theoretical analysis. Forest Sci. 17: 64-72.

373. Haines, Donald A., and Gerald H. Updike. 1971. Fire whirlwind formation over flat terrain. USDA Forest Serv. Res. Pap. NC-71, 12 p.

374. Hough, W. A. 1971. Fuel Science. In Proc. Fire Research Workshop, Macon, Ga., and Knoxville, Tenn., p. 16-18. (SE)

375. Kuehnast, Earl C., and Donald A. Haines. 1971. Unusual features observed within a series of tornado pictures. Mon. Weather Rev. 99(6): 545-548. (NC)

376. Murray, J. R., L. I. Northcutt, and C. M. Countryman. 1971. Measuring mass loss rates in free-burning fires. Fire Tech. 7(2): 162-169. (PSW)

377. Ouano, A. C., A. Broido, Edward M. Barrall, II, and A. C. Javier-Son, 1971. Gel permeation chromatography: molecular weight averages and molecular weight distribution of cellulose nitrate. Polymer Preprints 12: 859-864. (PSW)

378. Palmer, T. Y., and L. I. Northcutt. 1971. A high temperature water-cooled anemometer. Fire Tech. 7(3): 201-204. (PSW)

379. Philpot, Charles W. 1971. The pyrolysis products and thermal characteristics of cottonwood and its components. USDA Forest Serv. Res. Pap. INT-107, 31 p. (INT)

380. Philpot, Charles W. 1971. The pyrolytic effect of treating cottonwood with plant ash. USDA Forest Serv. Res. Note INT-139, 5 p. (INT)

381. Philpot, Charles W., and Robert W. Mutch. 1971. The seasonal trends in moisture content, ether extractives, and energy of ponderosa pine and Douglas-fir needles. USDA Forest Serv. Res. Pap. INT-102, 21 p. (INT)

382. Roe, Arthur L., William R. Beaufait, L. Jack Lyon, and Jerry L. Oltman. 1971. Fire and Forestry. . .a task force report. J. Forest. 68: 464-470. (INT)

383. Sackett, Stephen S. 1971. A circular-impact sampler for forest litter. USDA Forest Serv. Res. Note SE-169, 6 p. (SE)

384. Slaughter, C. W., Richard J. Barney, and G. M. Hansen. 1971. Fire in the northern environment--a symposium. Pac. NW Forest and Range Exp. Sta. 275 p. (PNW)

385. Wilson, Carl C., and John D. Dell. 1971. The fuels buildup in American forests: a plan of action and research. J. Forest. 68(8): 471-475. (PSW)

Remote sensing methods

386. Beall, R. C., O. W. Gastineau, and J. D. Bortz. 1972. Determining the volume of chip piles using small-camera, vertical aerial photography. Mont. Forest and Conserv. Exp. Sta., Univ. of Mont. Res. Note No. 10, 2 p. (INT)

387. Hirsch, Stanley N. 1971. Application of infrared scanners to forest fire detection. In Proc. Int. Workshop Earth Resources Surv. Syst., Vol. 2: 153-169. (INT)

388. Hirsch, Stanley N. 1971. Fire intelligence. In Proc. Employment of Air Operations in the Fire Services, Argonne, Ill., p. 127-144. (INT)

389. Hirsch, S. N., R. F. Kruckeberg, and F. H. Madden. 1971. The bispectral forest fire detection system. In Proc. Seventh Symp. Remote Sensing Environ. 3:2253-2272. (INT)

390. Kruckeberg, Robert F. 1971. No smoke needed. USDA Forest Serv. Fire Control Notes 32(2): 9-11. (INT)

391. Kruckeberg, Robert F. 1972. More accurate scanner, faster aircraft tested. USDA Forest Serv. Fire Control Notes 33(1): 11-13. (INT)

392. Kourtz, Peter H. 1971. An operations research approach to the optimizing of the fire detection system. In Proc. Int. Union Forest Res. Organ., 44 p. (INT)

393. Kourtz, Peter H., and W. G. O'Regan. 1971. A model for a small forest fire... to simulate burned and burning areas for use in a detection model. Forest Sci. 17(2): 163-169. (INT)

394. Madden, Forrest H. 1971. A new system for detecting latent forest fires. In Proc. Region Six Conf. Inst. Elec. and Electron. Eng. 6B-2, 8 p. (INT)

395. Maxwell, Floyd O. 1971. A portable IR system for observing fire thru smoke. Fire Tech. 7(4): 321-331. (PSW)

396. O'Regan, William G., and Peter H. Kourtz. 1971. A managerial system for an airborne infrared detection device. In Proc. Region Six Conf. Inst. Elec. and Electron. Eng. 6B-1, 5 p. (INT)

397. Wilson, Ralph A., S. N. Hirsch, B. J. Losensky, and F. H. Madden. 1971. Airborne infrared forest fire detection system: final report. USDA Forest Serv. Res. Pap. INT-93, 99 p. (INT)

Fire and forest meteorology

398. Cramer, Owen P., and H. E. Graham. 1971. Cooperative management of smoke from slash fires. J. Forest. 69(6): 327-331. (PSW)

399. Cramer, Owen P. 1972. Potential temperature analysis for mountainous terrain. J. Applied Meteor. 11(1): 44-50. (PSW)

400. Fuquay, D. M., and R. G. Baughman. 1971. Report on studies of Rocky Mountain lightning storms. In Proc. Thirteenth Interagency Conf. on Weather Modification, Shenandoah National Park, Va. (In press.) (INT)

401. Garstang, M., N. E. LaSeur, K. L. Warsh, R. Hadlock, and J. R. Peterson. 1970. Atmospheric-oceanic observations in the tropics. Amer. Sci. 58(5):482-495. (SE)

402. Roberts, Charles F. 1971. A note on the derivation of a scale measure for precipitation events. Mon. Weather Rev. 99(11): 873-876. (WO)

403. Ryan, Bill C., G. R. Ellis, and D. V. Lust. 1971. Low-level wind maxima on the 1969 San Mateo and Walker Fires. USDA Forest Serv. Res. Pap. PSW-75, 10 p. (PSW)

404. Smith, D. L. 1970. The application of digitized radar data to the prediction of summertime convective activity in coastal regions. In Proc. 14th Radar Meteor. Conf., Tucson, Ariz., p. 347-352. (SE)

405. Taylor, Alan R. 1971. Lightning: agent of change in forest ecosystems. J. Forest. 68(8): 476-480. (INT)

406. Trigg, William M. 1971. Fire season climatic zones of mainland Alaska. USDA Forest Res. Pap. PNW-126, 13 p. (PNW)

407. Williams, D. T. 1971. Weather and fire behavior. In Proc. Fire Research Workshop, Macon, Ga., and Knoxville, Tenn., p. 11-15. (SE)

FOREST DISEASE RESEARCH

Root diseases

408. Bakshi, B. K., M. A. Ram Reddy, and B. Singh. 1970. An unrecorded decay of living deodar. Indian Forest. 96: 72-74. (WO)[1]

409. Berry, F. H. 1971. Eight years' loss from Fomes annosus in thinned shortleaf pine plantations in Missouri. Plant Disease Rept. 55: 1085-1087. (NE)

410. Churchill, R. C., Jr., and J. L. Ruehle. 1971. Occurrence, parasitism, and pathogenicity of nematodes associated with sycamore (Platanus occidentalis L.). J. Nematol. 3: 189-196. (SE)

411. Hendrix, F. F., Jr., and W. A. Campbell. 1971. A new species of Pythium with spiny oogonia and large chlamydospores. Mycologia 63: 978-982. (SE)

412. Hendrix, F. F., Jr., W. A. Campbell, and C. Y. Chien. 1971. Some Phycomycetes indigenous to soils of old growth forests. Mycologia 63: 283-289. (SE)

413. Hodges, C. S., Jr., J. W. Koenigs, E. G. Kuhlman, and E. W. Ross. 1971. Fomes annosus: a bibliography with subject index--1960-1970. USDA Forest Serv. Res. Pap. SE-84, 75 p. (SE)

414. Kuhlman, E. G., and C. G. Wells. 1971. Phytophthora root rot and fertilization damage in Christmas tree plantations. Amer. Christmas Tree J. 15: 17-20. (SE)

415. Li, C. Y., K. C. Lu, J. M. Trappe, and W. B. Bollen. 1972. Poria weirii-inhibiting and other phenolic compounds in roots of red alder and Douglas-fir. Microbios 5: 65-68. (PNW)

416. Marx, D. H. 1971. Ectomycorrhizae as biological deterrents to pathogenic root infections. In Mycorrhizae. E. Hacskaylo (ed.), Proc. of 1st N. Amer. Conf. on Mycorrhizae, April 1969. USDA Misc. Pub. 1189, p. 81-86. (SE)

417. Marx, D. H. 1971. Pecan mycorrhizae--a partnership between fungi and pecan roots. The Pecan Quarterly 5: 4-7. (SE)

418. Marx, D. H. 1971. The beneficial relationship between tree roots and mycorrhizal fungi. Arborists' News 36: 89-94. (SE)

419. Marx, D. H. 1972. Mycorrhizae--A type of root infection beneficial to plant growth. Agrichemical Age 15: 13-14, 16. (SE)

420. Marx, D. H., and W. C. Bryan. 1971. Formation of ectomycorrhizae on half-sib progenies of slash pine in aseptic culture. Forest Sci. 17: 488-492. (SE)

421. Marx, D. H., W. C. Bryan, and W. A. Campbell. 1971. Effect of endomycorrhizae formed by Endogone mosseae on growth of citrus. Mycologia 63: 1222-1226. (SE)

422. Nelson, E. E. 1972. Effect of urea and wood shavings in populations of soil microfungi, especially Trichoderma species. Microbios 5: 69-72. (PNW)

423. Palmer, J. G. 1971. Techniques and procedures for culturing ectomycorrhizal fungi. In Mycorrhizae. E. Hacskaylo (ed.), Proc. 1st N. Amer. Conf. Mycorrhizae, April 1969. USDA Misc. Pub. 1189, p. 132-144. (FPL)

424. Parker, J., and D. R. Houston. 1971. Effects of repeated defoliation on root and root collar extractives of sugar maple trees. Forest Sci. 17 (1): 91-95. (NE)

---

[1] This publication begins the list for Forest Disease Research.

425. Riffle, J. W. 1971. Effect of nematodes on root-inhibiting fungi. In Mycorrhizae. E. Hacskaylo (ed)., Proc. 1st N. Amer. Conf. on Mycorrhizae, April 1969. USDA Forest Serv. Misc. Pub. 1189, p. 97-113. (RM)

426. Ross, E. W. 1971. Control of Fomes annosus in the Third Forest. Proc. 1971 Southern Regional Tech. Conf., Soc. Amer. Forest., May 25-28, 1971, Jacksonville, Fla., p. 323-327. (SE)

427. Ross, E. W. 1971. A new control for Fomes annosus. Forest Farmer 31: 6-7, 16, 18. (SE)

428. Ruehle, J. L. 1972. Pathogenicity of Xiphinema chambersi on sweetgum. Phytopathology 62: 333-336. (SE)

429. Ruehle, J. L. 1971. Nematodes parasitic on forest trees. III. Reproduction on selected hardwoods. J. Nematol. 3: 170-173. (SE)

430. Ruehle, J. L. 1971. Reaction of two races of sand pine (Pinus clausa) to parasitism by the lance nematode, Hoplolaimus galeatus. (Abstr.) J. Nematol. 3: 328-329. (SE)

431. Ruehle, J. L., and W. A. Campbell. 1971. Adaptability of geographic selections of shortleaf pine to littleleaf sites. USDA Forest Serv. Res. Pap. SE-87. (SE)

432. Trappe, J. M. 1971. The mycorrhiza-forming ascomycetes. In Mycorrhizae. E. Hacskaylo (ed.), Proc. 1st N. Amer. Conf. on Mycorrhizae, April 1969. USDA Misc. Pub. 1189, p. 19-37. (PNW)

433. Wargo, P. M. 1971. Seasonal changes in carbohydrate levels of sugar maple. USDA Forest Serv. Res. Pap. NE-213, 8 p. (NE)

434. Wargo, P. M. 1971. Enhanced growth of Armillaria mellea on extracts from roots of defoliated sugar maple trees. (Abstr.) Phytopathology 61: 914. (NE)

435. Wear, J. F. 1971. Detection of root disease impacts on forest stands by sequential orbital and suborbital multispectral photography. In Monitoring forest land from high altitude and from space. 6th Annual Progress Report. Available in microfiche from NASA, Washington, D.C., Scientific and Technical Aerospace Reports. (PSW)

436. Wear, J. F. 1972. Potentiality for obtaining Poria disease signatures in Oregon Cascades from orbital altitudes. 4th Annual Earth Resources Aircraft Program Review. NASA Manned Spacecraft Center, Houston, Texas. (PSW)

437. Weiss, M. J., and J. W. Riffle. 1971. Armillaria root rot in a ponderosa pine plantation in New Mexico. Plant Disease Rept. 55: 823-824. (RM)

438. Zak, B. 1971. Detoxication of autoclaved soil by a mycorrhizal fungus. USDA Forest Serv. Res. Note PNW-159, 4 p. (PNW)

439. Zak, B. 1971. Characterization and identification of Douglas-fir mycorrhizae. In Mycorrhizae. E. Hacskaylo (ed.), Proc. 1st N. Amer. Conf. on Mycorrhizae, April 1969. USDA Misc. Pub. 1189, p. 38-53. (PNW)

440. Zak, B. 1971. Characterization and classification of mycorrhizae of Douglas-fir. II. Pseudotsuga menziesii + Rhizopogon vinicolor. Can. J. Bot. 49: 1079-1084. (PNW)

Stem cankers

441. Anderson, G. W. 1971. Aerially applied antibiotics fail to control Hypoxylon canker on aspen. Plant Disease Rept. 55: 650. (NC)

442. Bingham, R. T., and J. Gremmen. 1971. A proposed international program for testing blister rust resistance. Europ. J. Forest Path. 1: 93-100. (INT)

443. Czabator, F. J. 1971. Fusiform rust of southern pines--a critical review. USDA Forest Serv. Res. Pap. SO-65, 39 p. (SO)

444. Davis, R. T., and G. A. Snow. 1971. Forecasting weather favorable for fusiform rust infection. USDA Forest Serv. Tree Plant. Notes 22: 3-4. (SO)

445. Dwinell, L. D. 1971. Interaction of Cronartium fusiforme and Cronartium quercuum with Quercus velutina. Phytopathology 61: 1055-1058. (SE)

446. Filer, T. H., Jr., F. I. McCracken, C. A. Mohn, and W. K. Randall. 1971. Septoria canker on nursery stock of Populus deltoides. Plant Disease Rept. 55: 460-463. (SO)

447. Harvey, A. E., and J. L. Grasham. 1971. Inoculation of nonhost tissue culture with Cronartium ribicola. Can. J. Bot. 49: 881-882. (INT)

448. Harvey, A. E., and J. L. Grasham. 1971. Production of the nutritional requirements for growth of Cronartium ribicola by a nonhost species. Can. J. Bot. 49: 1517-1519. (INT)

449. Harvey, A. E., J. L. Grasham, and C. C. Waldron. 1971. The effects of growth regulating compounds on healthy and blister rust-infected tissue cultures of Pinus monticola. Phytopathology 61: 507-509. (INT)

450. Harvey, A. E., and J. Y. Woo. 1971. Histopathology and cytology of Cronartium ribicola in tissue cultures of Pinus monticola. Phytopathology 61: 773-779. (INT)

451. Hinds, T. E. 1972. Ceratocystis canker of aspen. Phytopathology 62: 213-220. (RM)

452. Hinds, T. E. 1972. Insect transmission of Ceratocystis species associated with aspen cankers. Phytopathology 62: 221-225. (RM)

453. Hoff, R. J., and G. I. McDonald. 1971. Resistance to Cronartium ribicola in Pinus monticola: Short-shoot fungicidal reaction. Can. J. Bot. 49: 1235-1239. (INT)

454. Jensen, K. F., and E. Reynolds. 1971. Response of Fusarium solani to fluctuating temperatures. USDA Forest Serv. Res. Pap. NE-210, 7 p. (NE)

455. Kessler, K. J., Jr. 1971. Stem abnormalities of yellow birch seedlings in Michigan and Wisconsin. Plant Disease Rept. 55: 788-790. (NC)

456. Krebill, R. G. 1971. Effect of low temperature on germination of teliospores of Cronartium ribicola. (Abstr.) Phytopathology 61: 899. (INT)

457. Krebill, R. G., and Y. Hiratsuka. 1972. Nuclear condition and possible life cycle of Peridermium ephedrae. The Southwestern Naturalist 16: 432-433. (INT)

458. Martin, N. E. 1972. Influence of blister rust on inorganic solute concentrations in western white pine. Phytopathology 62: 226-229. (INT)

459. Powers, H. R., Jr. 1971. Variation in shape of rust gall on loblolly pine. Plant Disease Rept. 55: 623-625. (SE)

460. Powers, H. R., Jr. 1972. Comandra rust on southern pines. J. Forest. 70: 18-20. (SE)

461. Powers, H. R., Jr., H. J. Duncan, L. D. Dwinell, and T. Miller. 1971. Inoculation of loblolly pines with Cronartium fusiforme at different levels of intensity. 11th South. Conf. Forest Tree Impt. Proc., p. 80-84. (SE)

462. Ross, E. W. 1971. Diplodia theobromae and Ceratocystis fimbriata f. platani found in silage sycamore plantings. Plant Disease Rept. 55: 741-743. (SE)

463. Steinhoff, R. J. 1971. Field levels of infection of progenies of western white pines selected for blister rust resistance. USDA Forest Serv. Res. Note INT-146, 6 p. (INT)

Dwarf mistletoes

464. Bakshi, B. K., and Y. N. Puri. 1971. Dwarf mistletoe on blue pine in the western Himalayas and its control. Indian Forest. 97: 547-552. (WO)

465. Baranyay, J. A., F. G. Hawksworth, and R. B. Smith. 1971. Glossary of dwarf mistletoe terms. Can. For. Serv., Pacific Forest Res. Centre, Special Rept. P-2-71, 42 p. (RM)

466. Hawksworth, F. G., and D. Wiens. 1972. Biology and classification of dwarf mistletoes (Arceuthobium). USDA Agr. Handb. 401, 234 p. (RM)

467. Khanna, S. K., P. S. Krishman, and G. G. Sanwal. 1971. Inhibition of glucan phosphorylase in the leaves of Dendrophthoe falcata. Phytochemistry 10: 545-550. (WO)

468. Khanna, S. K., P. S. Krishman, and G. G. Sanwal. 1971. Glucan phosphorylase in the leaves of Dendrophthoe falcata: Purification and characterization of enzyme. Phytochemistry 10: 551-559. (WO)

469. Mark, W. R., and C. P. P. Reid. 1971. Lodgepole pine-dwarf mistletoe xylem water potentials. Forest Sci. 17: 740-741. (RM)

470. Myers, C. A., F. G. Hawksworth, and J. L. Stewart. 1971. Simulating yields of managed, dwarf-mistletoe-infested lodgepole pine stands. USDA Forest Serv. Res. Pap. RM-72, 15 p. (RM)

471. O'Neill, Kellie. 1970. Frankliniella Hawksworthi, a new species on dwarf mistletoe of ponderosa pine in southwestern United States (Thysanoptera: Thripidae). Entomol. Soc. Wash. Proc. 72: 454-458. (RM)

472. Scharpf, R. F., and J. R. Parmeter, Jr. 1971. Seed production and dispersal by dwarf mistletoe in overstory Jeffrey pines in California. USDA Forest Serv. Res. Note PSW-247, 5 p. (PSW)

473. Shea, K. R., and D. K. Lewis. 1971. Occurrence of dwarf mistletoe in sanitized ponderosa pine in south-central Oregon. Northwest Sci. 45: 94-99. (PNW)

474. Wiens, D., and B. Barlow. 1971. The cytogeography and relationships of the Viscaceous and Eremolepidaceous mistletoes. Taxon 20: 313-332. (RM)

Vascular wilts

475. Gregory, G. F. 1971. Correlation of isolability of the oak wilt pathogen with leaf wilt and vascular water flow resistance. Phytopathology 61: 1003-1005. (NE)

476. Gregory, G. F. 1971. Transpiration of bur oaks during oak wilt pathogenesis. (Abstr.) Phytopathology 61: 893. (NE)

477. Gregory, G. F., T. W. Jones, and P. McWain. 1971. Injection of benomyl into elm, oak, and maple. USDA Forest Serv. Res. Pap. NE-232, 9 p. (NE)

478. Jones, T. W. 1971. An appraisal of oak wilt control programs in Pennsylvania and West Virginia. USDA Forest Serv. Res. Pap. NE-204, 15 p. (NE)

479. Jones, T. W., and G. F. Gregory. 1971. An apparatus for pressure injection of solutions into trees. USDA Forest Serv. Res. Pap. NE-233, 7 p. (NE)

480. McWain, P., and G. F. Gregory. 1971. Solubilization of benomyl for xylem injection in vascular wilt disease control. USDA Forest Serv. Res. Pap. NE-234, 6 p. (NE)

481. Rexrode, O., and T. W. Jones. 1972. Oak bark beetle attacks on oak wilt trees in Missouri. Environ. Entomol. 1: 57-58. (NE)

482. Rexrode, C. O., R. P. True, and R. R. Jones. 1971. Influence of three herbicides on mat production and bark beetle attack on oak wilt trees. Plant Disease Rept. 55: 1106-1107. (NE)

Foliage diseases

483. Brookhouser, L. W., and G. W. Peterson. 1971. Infection of Austrian, Scots, and ponderosa pines by Diplodia pinea. Phytopathology 61: 409-414. (RM)

484. Czabator, F. J., J. M. Staley, and G. A. Snow. 1971. Extensive southern pine needle blight during 1970-1971, and associated fungi. Plant Disease Rept. 55: 764-766. (SO)

485. Kais, A. G. 1971. Dispersal of Scirrhia acicola spores in southern Mississippi. Plant Disease Rept. 55: 309-311. (SO)

486. Nicholls, T. H., and G. W. Hudler. 1971. Dothistroma pini on Pinus nigra in Minnesota. Plant Disease Rept. 55: 1040. (NC)

487. Scharpf, R. F. 1972. Know your forest diseases--Elytroderma needle disease of pines. In Forest Pest Conditions in California, 1971. California Forest Pest Control Action Council. (PSW)

488. Skilling, D. D., and T. H. Nicholls. 1971. Lophodermium pinastri--a new disease problem in Scotch pine Christmas tree plantations. Plant Disease Rept. 55: 1116-1117. (NC)

489. Smith, R. S., Jr. 1972. Needle casts of high altitude white pines in California. Plant Disease Rept. 56: 102-103. (PSW)

Air pollution

490. Dochinger, L. S., A. M. Townsend, and D. M. Seegrist. 1971. Responses of hybrid poplar trees to sulfur dioxide fumigation. (Abstr.) J. Air Pollut. Contr. Assoc. Digest 64: 101. (NE)

491. Evans, L. S., and P. R. Miller. 1972. Ozone damage to ponderosa pine--a histological and histochemical appraisal. Amer. J. Bot. 59: 297-304. (PSW)

492. Freeman, W. L., Jr., L. S. Dochinger, and R. G. Doerner. 1971. Forest Service research and action programs for abatement of air pollution. Southern Lumberman 223: 87-88. (NE)

493. Miller, P. R., and A. A. Millecan. 1971. Extent of oxidant air pollution damage to some pines and other conifers in California. Plant Disease Rept. 55: 555-559. (PSW)

494. Roberts, B. R., A. M. Townsend, and L. S. Dochinger. 1971. Photosynthetic responses to SO_2 fumigation in red maple. (Abstr.) Plant Physiol. 47: 30. (NE)

Wood deterioration

495. Aho, P. E. 1971. Decay of Engelmann spruce in the Blue Mountains of Oregon and Washington. USDA Forest Serv. Res. Pap. PNW-116, 16 p. (PNW)

496. Amburgey, T. L. 1971. Nuclear phenomena preceding basidiospore formation by monobasidiospore isolates of Lenzites trabea. (Abstr.) Phytopathology 61: 883. (SO)

497. Amburgey, T. L. 1971. Annotated bibliography on prevention and control of decay in wooden structures (including boats). South. Forest Exp. Sta. mimeo., 123 p. (SO)

498. Amburgey, T. L. 1971. Hazards of earthfill construction. Pest Contr. 39: 34-36. (SO)

499. Andrews, S. R. 1971. Red rot of ponderosa pine. USDA For. Pest Leaflet 123, 8 p. (RM)

500. De Groot, R. C., and F. J. Czabator. 1971. Surface stain on sapwood of partially wetted longleaf pine logs. (Abstr.) Phytopathology 61: 889. (SO)

501. De Groot, R. C., and H. W. Scheld. 1971. Biodegradability of sapwood from southern pine logs stored under a continuous water spray. Forest Prod. J. 21: 53-55. (SO)

502. Eslyn, W. E. 1971. Reliability of a method for measuring specific gravity to determine wood losses in outside chip storage. Tappi 54: 1269-1270. (FPL)

503. Feist, W. C., W. E. Eslyn, E. L. Springer, and G. J. Hajny. 1971. Determining loss of wood substance after fungal attack. A comparison of two methods. Tappi 54: 1271-1273. (FPL)

504. Highley, T. L., and T. C. Scheffer. A need for modifying the soil-block method for testing natural resistance to white rot. Mat. und Organismen 5: 281-292. (FPL)

505. Highley, T. L., T. C. Scheffer, and M. L. Selbo. 1971. Wood minesweepers are sound after 15 years of service. Forest Prod. J. 21: 46-48. (FPL)

506. Houston, D. R. 1971. Chemical limitation of discoloration and decay associated with wounds in red maple and yellow birch. (Abstr.) Phytopathology 61: 896. (NE)

507. Houston, D. R. 1971. Discoloration and decay in red maple and yellow birch: Reduction through wound treatment. Forest Sci. 17: 402-406. (NE)

508. Kirk, T. K. 1971. Effects of microorganisms on lignin. Ann. Rev. Phytopath. 9: 185-210. (FPL)

509. Koenigs, J. W. 1972. Production of extracellular hydrogen peroxide and peroxidase by wood-rotting fungi. Phytopathology 62: 100-110. (SE)

510. Koenigs, J. W. 1971. The effect of H_2O_2 under acid conditions on strength, swelling, alkali solubility, reducing capacity and weight loss of cellulose. (Abstr.) Phytopathology 61: 899. (SE)

511. Scheffer, T. C., A. F. Verrall, and G. Harvey. 1971. Fifteen-year appraisal of dip treating for protecting exterior woodwork: effectiveness on different wood species and in various climates. Mat. und Organismen 6: 27-44. (PNW)

512. Scheld, H. W., and R. C. De Groot. 1971. Toughness of sapwood in water-sprayed longleaf pine logs. Forest Prod. J. 21: 33-34. (SO)

513. Shigo, A. L. 1971. Successions of microorganisms and patterns of discoloration and decay following wounding in deciduous hardwoods. 2nd Internat. Symposium on Plant Pathol. Proc., Indian Agr. Res. Inst., New Delhi-12, p. 175. (NE)

514. Shigo, A. L. 1971. Discoloration and decay in oak. Oak Symposium Proc., USDA Forest Serv., Northeast. Forest Exp. Sta., Upper Darby, Pa., p. 135-141. (NE)

515. Shigo, A. L. 1971. Successions of microorganisms and patterns of discoloration and decay after wounding in red oak and white oak. (Abstr.) Phytopathology 61: 910. (NE)

516. Shigo, A. L., J. Stankewich, and B. J. Cosenza. 1971. Clostridium sp. associated with discolored tissues in living oaks. Phytopathology 61: 122-123. (NE)

517. Stankewich, J. P., B. J. Cosenza, and A. L. Shigo. 1971. Clostridium quercicolum sp. n., isolated from discolored tissues in living oak trees. Antonie van Leeuwenhoek 37: 299-302. (NE)

518. Verrall, A. F. 1971. Durability of water-resisting treatments on wood siding. Forest Prod. J. 21: 57-58. (SO)

Forest fungi

519. Anonymous. 1971. Ganoderma lucidum, a destructive pathogen of Dalbergia sissoo. Pakistan Forest Inst., Peshawar, Leaflet No. 2, 2 p. (WO)

520. Bakshi, B. K., M. A. Ram Reddy, S. Singh, and P. C. Pandey. 1970. Disease situation in Indian forests. 1. Stem diseases of some exotics due to Corticium salmonicolor and Monochaetia unicornis. Indian Forest. 96: 826-829. (WO)

521. Davidson, R. W. 1971. New species of Ceratocystis. Mycologia 63: 5-15. (RM)

522. Hodges, C. S., and M. E. Barr. 1971. A new species of Pseudomassaria and its Beltraniella conidial state. Mycologia 63: 562-566. (SE)

523. Fridrich, J. H., A. E. Rich, and A. L. Shigo. 1971. Fungi isolated from fruits and seeds of some northern hardwood trees. Rhodora 73: 306-308. (NE)

524. Furman, T. E., and J. M. Trappe. 1971. Phylogeny and ecology of mycotrophic achlorophyllous angiosperms. Quart. Rev. Biol. 46: 219-225. (PNW)

525. Korf, R. P., and H. H. Burdsall, Jr. 1971. Common fungi: edible and poisonous. Cornell Univ. Ext. Bull., N.Y. State Coll. of Agr. Bull. 386, 16 p. (FPL)

526. Kuhlman, E. G., and C. S. Hodges, Jr. 1972. Rediscovery of Mortierella rostafinskii and Mortierella strangulata. Mycologia 64: 92-98. (SE)

527. Larsen, M. J. 1971. Notes on Tomentelloid fungi. III. New species of Pseudotomentella. Torrey Bot. Club Bull. 98: 38-41. (FPL)

528. Miller, O. K., Jr. 1971. The genus Gomphidius with a revised description of the Gomphidiaceae and key to the genera. Mycologia 63: 1129-1163. (FPL)

529. Miller, O. K., Jr., and L. Stewart. 1971. The genus Lentinellus Karsten. Mycologia 63: 333-369. (FPL)

530. Quaraishi, M. A., and M. Ahmad. 1971. New fungal records on Morus alba. Pakistan J. For. 21: 303-312. (WO)

531. Ram Reddy, M. A., R. K. Tewari, and B. K. Bakshi. 1971. Target leafspot disease of Rauwolfia serpentina and its chemical control. Indian Forest. 97: 487-491. (WO)

532. Trappe, J. M. 1971. The ecological basis for truffle cultivation and potential for expanded production. 1st Internat. Mycol. Congr. Abstr., p. 94. (PNW)

533. Trappe, J. M. 1971. The ascus in taxonomy and phylogeny of the Tuberales. 1st Internat. Mycol. Congr. Abstr., p. 93. (PNW)

534. Trappe, J. M. 1971. A synopsis of the Carbomycetaceae and Terfeziacea. Brit. Mycol. Soc. Trans. 57: 85-92. (PNW)

535. Trappe, J. M., and G. Guzman. 1971. A newly determined species of Elaphomyces from Oregon. Madrono 21: 128-130. (PNW)

536. Trappe, J. M., and G. Guzman. 1971. A newly determined species of Elaphomyces from Oregon. Madrono 21: 128-130. (PNW)

537. Watling, R., and O. K. Miller, Jr. 1971. Notes on eight species of Coprinus of the Yukon Territory and adjacent Alaska. Can. J. Bot. 49: 1687-1690. (FPL)

Miscellaneous studies

538. Baur, P. S., C. H. Walkinshaw, V. E. Scholes, and S. Venketeswaran. 1971. Synthesis of ergostic material in pine tissue cultures. Proc. 11th Ann. Meeting, Amer. Soc. for Cell Biology, Nov. 17-20, p. 342. (SO)

539. Bingham, R. T., R. J. Hoff, and G. I. McDonald. 1971. Disease resistance in forest trees. Annu. Rev. Phytopath. 9: 433-452. (INT)

540. DeBarr, G. L., and F. R. Matthews. 1971. Mist-blower applications for control of flower thrips and southern cone rust in

a slash pine seed orchard. J. Econ. Entomol. 64: 520-522. (SE)

541. Gregory, G. F., and K. F. Jensen. 1971. A modified Lowry protein test for dilute protein solutions. USDA Forest Serv. Res. Note NE-136, 3 p. (NE)

542. Haissig, B. E., and A. L. Schipper, Jr. 1971. Effect of ionic strength on recovery of plant enzymes in extracts prepared with anion exchange resin. Biochem. Biophys. Res. Commun. 45: 598-605. (NC)

543. Hepting, G. H. 1971. Diseases of forest and shade trees of the United States. USDA Agr. Handb. 386, 658 p. (WO)

544. Hinds, T. E., and P. E. Buffam. 1971. Blue stain in Engelmann spruce trap trees treated with cacodylic acid. USDA Forest Serv. Res. Note RM-201, 4 p. (RM)

545. Hock, W. K., and L. S. Dochinger. 1971. Chemotherapeutic control of stem crown gall of Sherrill hybrid poplar trees. (Abstr.) Phytopathology 61: 129. (NE)

546. Houston, D. R. 1971. Noninfectious diseases of oaks. Oak Symposium Proc., USDA, Forest Serv. Northeast. Forest Exp. Sta., Upper Darby, Pa., p. 118-123. (NE)

547. Johnson, P. H., C. H. Walkinshaw, J. R. Martin, W. B. Nance, and A. D. Bennett. 1972. Elemental analysis of Apollo 15 surface fines used in biological studies at the Lunar Receiving Laboratory. BioScience 22: 96-99. (SO)

548. Kessler, K. J., Jr., and R. W. Blank. 1971. An inexpensive temperature-gradient incubator. USDA Forest Serv. Res. Note NC-119, 2 p. (NC)

549. Laseter, J. L., J. D. Weete, A. Albert, and C. H. Walkinshaw. 1971. Gas chromatographic determination of trimethysilyl derivatives of free amino acids from a botanical source. Analytical Letters 4: 671-681. (SO)

550. Leaphart, C. D., and A. R. Stage. 1971. Climate: A factor in the origin of the pole blight disease of Pinus monticola Dougl. Ecology 52: 229-239. (INT)

551. Krebill, R. G. 1972. Preliminary annotated list of diseases of shrubs on western game ranges. USDA Forest Serv. Res. Note INT-156, 8 p. (INT)

552. Paine, L. A. 1971. Accident hazard evaluation and control decisions on forested recreation sites. USDA Forest Serv. Res. Pap. PSW-68, 11 p. (PSW)

553. Parker, J. 1971. An unusual tonoplast in conifer leaves. Nature 234 (5326): 231. (NE)

554. Parker, J. 1971. Heat resistance and respiratory response in twigs of some common tree species. Bot. Gaz. 132: 268-273. (NE)

555. Powers, H. R. 1971. Tree diseases in an urban environment. Symposium on the Role of Trees in the South's Urban Environment. The Univ. of Georgia Center for Continuing Education. p. 44-50. (SE)

556. Rier, J. P., and A. L. Shigo. 1971. Some early wounding responses in red maple, Acer rubrum. Amer. J. Bot. 58: 456. (NE)

557. Rowan, S. J. 1971. Nursery diseases. Proc. Southeast. Area Forest Nurserymen Conf., Lake Barkley, Ky., 1970, p. 37-41. (SE)

558. Semeniuk, P., and J. G. Palmer. 1971. Control of rose blackspot in the field with benomyl. J. Amer. Soc. Hort. Sci. 96: 620-622. (FPL)

559. Shigo, A. L. 1971. Trees need your help, too. USDA. Forest Serv. NE-Information Bull., 4 p. (NE)

560. Shigo, A. L. 1971. The beech bark disease spreads southward. South. Lumberman 223: 83. (NE)

561. Shigo, A. L., and C. L. Wilson. 1971. Are tree wound dressings beneficial? Arborist's News 36: 85-88. (NE)

562. Smith, R. S., Jr., A. H. McCain, M. Srago, R. F. Krohn, and D. Peny. 1972. Control of Sirococcus tip blight of Jeffrey pine seedlings. Plant Disease Rept. 56: 241-242. (PSW)

563. Stewart, J. L., and K. R. Shea. 1971. Forest diseases of the Pacific Northwest. USDA Forest Serv. PNW Misc. Pap., 14 p. (PNW)

564. Trappe, J. M. 1971. Root pruning conifers in nursery beds: does it increase survival potential? Tree Planters' Notes 22: 13. (PNW)

565. Walkinshaw, C. H. 1971. Lunar-horticulture. HortScience 6: 518. (SO)

566. Walkinshaw, C. H. 1972. Comparative morphology of undifferentiated plant cells cultured in vitro. In Vitro 7: 261. (SO)

567. Walkinshaw, C. H., and P. H. Johnson. 1971. Analysis of vegetable seedlings grown in contact with Apollo 14 lunar surface fines. HortScience 6: 532-535. (SO)

568. Walkinshaw, C. H., and S. Venketeswaran. 1971. Usefulness of pine tissue cultures as test systems in forestry and space research. In Vitro 6: 379. (SO)

569. Walkinshaw, C. H., B. C. Wooley, and G. A. Bozarth. 1972. Technology advancements in the growth of germfree plants at the Manned Spacecraft Center. Proc. of IV Internat. Symp. on Germfree Res., April 16-22, New Orleans, La., p. 54. (SO)

570. Weete, J. D., and C. H. Walkinshaw. 1972. Apollo 12 lunar material: Effects on plant pigments. Can. J. Bot. 50: 101-104. (SO)

571. Weete, J. D., C. H. Walkinshaw, and J. L. Laseter. 1972. Apollo 12 lunar material: Effects on lipid levels of habituated tobacco tissue cultures. Science 175: 623-624. (SO)

572. Wilson, C. L., C. E. Seliskar, and C. R. Krause. 1972. Mycoplasmalike bodies associated with elm phloem necrosis. Phytopathology 62: 140-143. (NE)

FOREST INSECT RESEARCH

Life history and ecology of insects

573. Amman, G. D. 1972. Mountain pine beetle brood production in relation to thickness of lodgepole pine phloem. J. Econ. Entomol. 65: 138-140. (INT)[1]

574. Barcia, D. R., and E. P. Merkel. 1972. Bibliography on insects destructive to flowers, cones, and seeds of North American conifers. USDA Forest Serv. Res. Pap. SE-92, 80 p. (SE)

575. Barras, S. J. 1971. Miniature dissecting needle. Carolina Tips 34: 9-10. (SO)

576. Batzer, H. R., and R. C. Morris. 1971. Forest tent caterpillar. USDA Forest Pest Leafl. 9 (Rev.), 5 p. (NC)

577. Behr, E. A., C. T. Behr, and L. F. Wilson. 1972. Influence of wood hardness on feeding by the eastern subterranean termite, Reticulitermes flavipes (Isoptera: Rhinotermitidae). Ann. Entomol. Soc. Amer. 65: 457-460. (NC)

578. Bennett, W. H., and W. M. Ciesla. 1971. Southern pine beetle. USDA Forest Pest Leafl. 49 (Rev.), 8 p. (SO)

579. Burns, D. P. 1971. Insects that hurt the bourbon stave industry. The Wooden Barrel 38: 6-9. (NE)

[1] This publication begins the list for Forest Insect Research.

580. Burns, D. P., and D. E. Donley. 1971. Quantitative field collection of honeydew. Ann. Entomol. Soc. Amer. 64: 532-534. (NE)

581. Carlson, R. B., and L. F. Wilson. 1971. Zimmerman pine moth. USDA Forest Pest Leafl. 106 (Rev.), 7 p. (NC)

582. Carolin, V. M. Jr., and F. W. Honing. 1972. Western spruce budworm. USDA Forest Pest Leafl. 53 (Rev.), 8 p. (PNW)

583. Cole, W. E. 1971. Pine butterfly. USDA Forest Pest Leafl. 66 (Rev.), 3 p. (INT)

584. Cross, E. A., and J. C. Moser. 1971. Taxonomy and biology of some Pyemotidae (Acarina: Tarsonemoidea) inhabiting bark beetle galleries in North America conifers. Acarologia 13: 47-64. (SO)

585. DeBarr, G. L. 1971. The value of insect control in seed orchards: some economic and biological considerations. 11th South. Conf. Forest Tree Impr. Proc., Atlanta, Ga., 1971: 178-185. (SE)

586. DeBarr, G. L., and J. A. Williams. 1971. Nonlethal thrips damage to slash pine flowers reduces seed yields. USDA Forest Serv. Res. Note SE-160, 4 p. (SE)

587. Denton, R. E., and S. Tunnock. 1971. Larch casebearer in western larch forests. USDA Forest Pest Leafl. 96 (Rev.), 8 p. (INT)

588. Donley, D. E. 1971. Tuliptree scale damages Pennsylvania yellow poplar. Pa. Forests 61: 40-41. (NE)

589. Donley, D. E. 1971. Track the hickory nut weevil. Ohio Woodlands 9: 13. (NE)

590. Drooz, A. T., and A. E. Bustillo. 1972. Glena bisulca, a serious defoliator of Cupressus lusitanica in Colombia. J. Econ. Entomol. 65: 89-93. (SE)

591. Ebel, B. H. 1971. Distribution and incidence of Laspeyresia spp. seedworm infestation in Virginia, loblolly, and shortleaf pine cones in the southern States. 11th South. Conf. Forest Tree Impr. Proc., Atlanta, Ga., 1971: 95-97. (SE)

592. Ebel, B. H., E. P. Merkel, and R. J. Kowal. 1971. Key to forest tree insects of the South. Forest Farmer Manual 30(7): 96-102. (SE)

593. Fatzinger, C. W., and M. T. Proveaux. 1971. A hydraulically operated pine cone cutter. USDA Forest Serv. Res. Note SE-165, 5 p. (SE)

594. Fowler, R. F., and L. F. Wilson. 1971. White grub populations, Phyllophaga spp., in relation to damaged red pine seedlings in Michigan and Wisconsin plantations (Coleoptera: Scarabaeidae). Mich. Entomol. 4(1): 23-28. (NC)

595. Frayer, W. E., R. W. Wilson, and G. M. Furnival. 1971. FSCREEN (fast screen), a computer program for screening all combinations of independent variables in univariate multiple linear regressions. Dept. Forest and Wood Sciences, Colo. State Univ., Fort Collins, Colo. 23 p. (NE)

596. Furniss, M. M. 1971. Mountain-mahogany looper. USDA Forest Pest Leafl. 124, 5 p. (INT)

597. Furniss, M. M. 1972. A preliminary list of insects and mites that infest some important browse plants of western big game. USDA Forest Serv. Res. Note INT-155, 16 p. (INT)

598. Furniss, M. M. 1972. Poplar-and-willow borer. USDA Forest Pest Leafl. 121, 5 p. (INT)

599. Furniss, M. M., and J. A. E. Knopf. 1971. Western tussock moth. USDA Forest Pest Leafl. 120, 4 p. (INT)

600. Furnival, G. M., and R. W. Wilson, Jr. 1971. Systems of equations for predicting forest growth and yield. In Statistical Ecology. The Pa. State Univ. Press, Vol. 3, p. 43-55. (NE)

601. Goyer, R. A., G. D. Hertel, and D. M. Benjamin. 1971. Branch mortality of Scotch pine caused by pales weevil larvae. Amer. Christmas Tree J. 15: 33-34. (SE)

602. Hard, J. S. 1971. Effects of semistarvation during late larval stages on survival and fecundity of the hemlock sawfly in the laboratory. USDA Forest Serv. Res. Note PNW-157, 8 p. (PNW)

603. Howe, V. K., A. D. Oberle, T. G. Keeth, and W. J. Gordon. 1971. The role of microorganisms in the attractiveness of lightning-struck pines to southern pine beetles. West. Ill. Univ. Biol. Sci. Ser. 9, 44 p. (SO)

604. Jennings, D. T. 1971. Plant associations of Misumenops coloradensis Gertsch (Araneae: Thomisidae) in central New Mexico. Southwest. Nat. 16: 201-207. (RM)

605. Jennings, D. T. 1971. Ocular anomaly of Misumenops sp. (Araneae: Thomisidae). Southwest. Nat. 15: 503. (RM)

606. Jennings, D. T. 1971. Mechanically dislodging jack pine budworms. J. Econ. Entomol. 64: 978-979. (NC)

607. Kennedy, P. C., and L. F. Wilson. 1971. Understory vegetation associated with Saratoga spittlebug damage in Michigan red pine plantations. Can. Entomol. 103: 1421-1426. (NC)

608. Kennedy, P. C., and L. W. Wilson. 1971. Pine root collar weevil damage to red pine plantations in Michigan related to host age, temperature, and stand location. Can. Entomol. 103: 1685-1690. (NC)

609. Koerber, T. W., and G. R. Struble. 1971. Lodgepole needle miner. USDA Forest Pest Leafl. 22 (Rev.), 8 pp. (PSW)

610. Kowal, R. J., and B. H. Ebel. 1971. Insects attacking forest trees in the South. Forest Farmer Manual 30: 89-95. (SE)

611. MacAloney, H. J., and L. F. Wilson. 1971. The Saratoga spittlebug. USDA Forest Pest Leafl. 3 (Rev.), 6 p. (NC)

612. Maksimović, M., Z. Motal, D. Bartovcak, and M. Drndelić. 1971. A contribution to the study of elm dieback caused by the Dutch elm disease in the region of forest farm Bjelovar. Plant Prot. No. 112-113, 20 p. (PL-480--Yugoslavia.) (WO)

613. Massey, C. L. 1971. Omemeea maxbassiensis n. gen., n. sp. (Nematoda: Aphelenchoididae) from galleries of the bark beetle Leperisinus californicus Sw. (Coleoptera: Scolytidae) in North Dakota. J. Nematol. 3 (3): 289-291. (RM)

614. Massey, C. L. 1971. Arizona five-spined Ips. USDA Forest Pest Leafl. 116 (Rev.), 4 pp. (RM)

615. Mattson, W. J. 1971. Relationship between cone crop size and cone damage by insects in red pine seed-production areas. Can. Entomol. 103: 617-621. (NC)

616. McCambridge, W. F. 1971. Temperature limits of flight of the mountain pine beetle Dendroctonus ponderosae. Ann. Entomol. Soc. Amer. 64: 534-535. (RM)

617. Miller, W. E. 1971. Annual variation in starting date of spring feeding by the European pine shoot moth in a Michigan planting. Mich. Entomol. 4: 28-32. (NC)

618. Miller, W. E. 1971. Identification of Phaneta refusana (Walker) with description of a new species (Tortricidae). J. Lepidop. Soc. 25: 284-287. (NC)

619. Moser, J. C., and S. E. Neff. 1971. Pholeomyia comans (Diptera: Milichiidae) an associate of Atta texana; larval anatomy and notes on biology. Z. für Angew. Entomol. 69: 343-348. (SO)

620. Moser, J. C., and L. M. Roton. 1971. Mites associated with southern pine bark beetles in Allen Parish, Louisiana. Can. Entomol. 103: 1775-1798. (SO)

621. Nord, J. C. 1971. Soft maple + CTB = Soft maple (WHND) = $$? South. Lumberman 223(2776): 140-142. (SE)

622. Nord, J. C. 1972. Biology of the Columbia timber beetle, Corthylus columbianus (Coleoptera: Scolytidae), in Georgia. Ann. Entomol. Soc. Amer. 65: 350-358. (SE)

623. Nord, J. C., D. G. Grimble, and F. B. Knight. 1971. Biology of Saperda inornata (Coleoptera: Cerambycidae) in trembling aspen, Populus tremuloides. Ann. Entomol. Soc. Amer. 65: 127-135. (SE)

624. Nord, J. C., D. G. Grimble, and F. B. Knight. 1971. Biology of Oberea schaumii (Coleoptera: Cerambycidae) in trembling aspen, Populus tremuloides. Ann. Entomol. Soc. Amer. 65: 114-119. (SE)

625. Nord, J. C., and F. B. Knight. 1970. Saperda inornata Say, 1824, (Insecta, Coleoptera): Proposed use of the plenary posers to designate a neotype to stabilize the nomenclature. Z. N. (S) 1921. Bull. Zoo. Nomen. 27: 123-128. (SE)

626. Rexrode, C. O. 1971. Insect damage in oak. Oak Symp. Proc., Morgantown, W. Va., p. 129-134. (NE)

627. Sartwell, C. 1971. Ips pini (Coleoptera: Scolytidae) emergence per exit hole in ponderosa pine thinning slash. Ann. Entomol. Soc. Amer. 64: 1473-1474. (PNW)

628. Sartwell, C., R. F. Schmitz, and W. J. Buckhorn. 1971. Pine engraver, Ips pini, in the Western States. USDA Forest Pest Leafl. 122, 5 p. (PNW)

629. Schmid, J. M. 1971. Beetles in the spruce forests. Colo. Outdoors 20: 32-35. (RM)

630. Schmid, J. M. 1972. Emergence, attack densities, and seasonal trends of mountain pine beetle (Dendoctonus ponderosae) in the Black Hills. USDA Forest Serv. Res. Note RM-211, 7 p. (RM)

631. Schmid, J. M., and R. C. Beckwith. 1972. The spruce beetle. USDA Forest Pest Leafl. 127, 7 p. (PNW)

632. Sen-Sarma, P. K. 1971. Effect of relative humidity on the longevity of starving workers and soldiers of Heterotermes indicola (Wasm.) (Insecta: Isoptera). Proc. VI Congr. Internat'l. Union Study Social Insects, Bern, Switzerland, 1969, 4 p. (PL-480--India). (WO)

633. Sen-Sarma, P. K., and P. N. Chatterjee. 1970. Recent trends in laboratory evaluation of termite resistance of wood and wood products. J. Indian Acad. Wood Sci. 1: 119-128. (PL-480--India.) (WO)

634. Solomon, J. D., and E. R. Toole. 1971. Stain and decay around carpenter worm galleries in southern hardwood trees. USDA Forest Serv. Res. Note SO-120, 4 p. (SO)

635. Speers, C. F. 1971. Ips bark beetles in the South. USDA Forest Pest Leafl. 129 (Rev.), 7 p. (SE)

636. Speers, C. F., and B. H. Ebel. 1971. Pales and pitch-eating weevils: ratio and period of attack in the South. USDA Forest Serv. Res. Note SE-156, 5 p. (SE)

637. Stein, D., and C. Kennedy. 1972. Key to shelterbelt insects in the northern Great Plains. USDA Forest Serv. Res. Pap. RM-85, 153 p. (RM)

638. Stevens, R. E. 1971. Pine growth retarded following defoliation by the pine needle-sheath miner. J. Econ. Entomol. 64: 1572-1573. (RM)

639. Stevens, R. E. 1971. Ponderosa pine tip moth. USDA Forest Pest Leafl. 103 (Rev.), 5 p. (RM)

640. Stevens, R. E. 1971. Fir engraver. USDA Forest Pest Leafl. 13 (Rev.), 7 p. (RM)

641. Thomas, H. A. 1971. Integrated control of weevils attacking coniferous reproduction. J. Forest. 69: 806-808. (SE)

642. Wickman, B. E., G. C. Trostle, and P. E. Buffam. 1971. Douglas-fir tussock moth. USDA Forest Pest Leafl. 86. (Rev.), 6 p. (PNW)

643. Wilson, L. F. 1971. A portable cage for insect study in the field. Mich. Entomol. Soc. Newsl. 16: 1,3. (NC)

644. Wilson, L. F. 1971. Jack-pine sawfly. USDA Forest Pest Leafl. 17 (Rev.), 4 p. (NC)

645. Wilson, L. F. 1971. Pine tortoise scale. USDA Forest Pest Leafl. 57 (Rev.), 7 p. (NC)

646. Wilson, L. F. 1971. The green-striped mapleworm. USDA Forest Pest Leafl. 77 (Rev.), 4 p. (NC)

647. Wilson, L. F. 1971. Walkingstick. USDA Forest Pest Leafl. 82 (Rev.) 4 p. (NC)

648. Wilson, L. F. 1971. Introduced pine sawfly. USDA Forest Pest Leafl. 99 (Rev.), 4 p. (NC)

649. Wilson, L. F. 1971. Risk-rating Saratoga spittlebug damage by abundance of alternate-host plants. USDA Forest Serv. Res. Note NC-110, 4 p. (NC)

650. Wollerman, E. H. 1972. Contributions to locust borer biology. (Abstr.) Proc. N. Cent. Br. Entomol. Soc. Amer. 26: 37-40. (NE)

651. Yates, H. O., III. 1971. Insectos que atacan a Pinus caribaea en el nordeste de Nicaragua. Organ. de la Naciones Unidas para la Agric. y la Alimentacion FO:SE/NIC 9 Inform. Tech. 1 Pome. 13 p. (SE)

652. Yates, H. O., III. 1971. Nantucket pine tip moth-caused flower and conelet mortality. Eleventh South. Conf. Forest Tree Impr. Proc. Atlanta, Ga., 1971: 224-229. (SE)

653. Yates, H. O., III, and R. H. Beal. 1971. Nantucket pine tip moth. USDA Forest Pest Leafl. 70 (Rev.), 6 p. (SE)

654. Yates, H. O., III, and B. H. Ebel. 1972. Shortleaf pine conelet loss caused by the Nantucket pine tip moth Rhyacionia frustrana (Lepidoptera: Olethreutidae). Ann. Entomol. Soc. Amer. 65: 100-104. (SE)

Insect physiology, nutrition, and rearing

655. Addy, N. D. 1971. Some cytological changes in the fat body and testes of male spruce budworm (Choristoneura fumiferana Clem.) pupae after treatment with tepa. Can. J. Zool. 49: 831-836. (NC)

656. Asher, W. C. 1971. Selective blocking of somatic neuromuscular transmission in the larval wax moth, Galleria mellonella, by bromolysergic acid diethylamide. J. Insect Physiol. 17: 1801-1805. (SE)

657. Asher, W. C. 1971. "EAG's"--Animal, vegetable, and mineral. J. Elisha Mitchell Sci. Soc. 87: 161. (SE)

658. Batzer, H. O., and N. D. Addy. 1971. Release and recovery of phosphorus-32 tagged jack pine budworm larvae in the field (Lepidoptera: Tortricidae). Ann. Entomol. Soc. Amer. 64: 1185-1186. (NC)

659. Bedard, W. D., R. M. Silverstein, and D. L. Wood. 1970. Bark beetle pheromones. Science 167: 1638-1639. (PSW)

660. Bedard, W. D., P. E. Tilden, D. L. Wood, R. M. Silverstein, R. G. Brownlee, and J. O. Rodin. 1969. Western pine beetle: field response to its sex pheromone and a synergistic host terpene, myrcene. Science 164: 1284-1285. (PSW)

661. Carolin, V. M., G. E. Daterman, and W. K. Coulter. 1971. Techniques in obtaining overwintering larvae of European pine shoot moth for mass rearing. J. Econ. Entomol. 64: 1408-1410. (PNW)

662. Clark, E. W. 1971. Chemically defined diet for pales weevil larva. J. Elisha Mitchell Sci. Soc. 87: 161. (SE)

663. Clark, E. W., and J. D. White. 1971. Carbohydrate, amino acid, and inorganic constituents of leaves of two hosts of the elm spanworm. J. Econ. Entomol. 64: 1009-1011. (SE)

664. Daterman, G. E. 1972. Laboratory bioassay for sex pheromone of the European pine shoot moth, Rhyacionia buoliana. Ann. Entomol. Soc. Amer. 65: 119-123. (PNW)

665. Fatzinger, C. W., and W. C. Asher. 1971. Mating behavior and evidence for a sex pheromone of Dioryctria abietella (Lepidoptera: Pyralidae (Phycitinae)). Ann. Entomol. Soc. Amer. 64: 612-620. (SE)

666. Furniss, M. M., and R. F. Schmitz. 1971. Comparative attraction of Douglas-fir beetles to frontalin and tree volatiles. USDA Forest Serv. Res. Pap. INT-96, 16 p. (INT)

667. Galford, J. R. 1971. Improved techniques for rearing the smaller European elm bark beetle on artificial media. J. Econ. Entomol. 64: 1327-1328. (NE)

668. Happ, G. M., C. M. Happ, and S. J. Barras. 1971. Fine structure of the prothoracic mycangium, a chamber for the culture of symbiotic fungi, in the southern pine beetle, Dendroctonus frontalis. Tissue & Cell 3: 295-308. (SO)

669. Hertel, G. D. 1971. Rearing pales weevils on soil beds containing pine bolts. J. Econ. Entomol. 64: 893-895. (SE)

670. Mauldin, J. K., E. N. Lambremont, and J. B. Graves. 1971. Principal lipid classes and fatty acids synthesized during growth and development of the beetle Lyctus planicollis. Insect Biochem. 1: 316-326. (SO)

671. Peacock, J. W. 1971. Scolytus multistriatus (Marsham) as a source of pheromone. (Abstr.) Proc. No. Cent. Br. Entomol. Soc. Amer. 26: 92. (NE)

672. Peacock, J. W., A. C. Lincoln, J. B. Simeone, and R. M. Silverstein. 1971. Attraction of Scolytus multistriatus (Coleoptera: Scolytidae) to a virgin-female- produced pheromone in the field. Ann. Entomol. Soc. Amer. 64: 1143-1149. (NE)

673. Roberts, R. B., and H. W. Smith. 1971. Free amino acids in the eggs and hemolymph of the grasshopper Melanoplus sanquinipes (Orthoptera: Acrididae). 1. Identification and quantitative changes throughout development. Ann. Entomol. Soc. Amer. 64: 693-702. (PSW)

674. Roberts, R. B., and H. W. Smith. 1971. Free amino acids in the eggs and hemolymph of the grasshopper Melanoplus sanquinipes (Orthoptera: Acrididae). 2. Changes in composition as a result of diet and population and artificial stress. Ann. Entomol. Soc. Amer. 64: 703-708. (PSW)

675. Schmitz, R. F. 1972. A fiberglass cage for rearing bark beetles in small log sections. USDA Forest Serv. Res. Note INT- 154, 4 p. (INT)

676. Schmidt, F. H., and C. L. Young. 1971. Larval coloration in Choristoneura spp. (Lepidoptera: Tortricidae) bile pigment in hemolymph. J. Insect Physiol. 17: 843-855. (PNW)

677. Schwartz (Robertson), J. L., 1971. Inhibition of nerve cord metamorphosis in the western spruce budworm (Choristoneura occidentalis Freeman (Lepidoptera: Tortricidae) by juvenile hormone analogs. Gen. and Comp. Endocrinol. 17: 293-299. (PSW)

678. Silverstein, R. M. 1970. Attractant pheromones of coleoptera. In Chemicals Controlling Insect Behavior. Ed. M. Beroza, Acad. Press, N.Y., p. 21-40. (Grant) (WO)

679. Silverstein, R. M. 1970. Methodology for isolation and identification of insect pheromones--examples from Coleoptera. In Control of Insect Behavior by Natural Products. Eds. D. L. Wood, R. M. Silverstein, and M. Nakajima, Acad. Press, N.Y., p. 285-299. (Grant) (WO)

680. Smith, R. F. 1971. Effects of neurotropic drugs on Lannate and atropine toxicity in the western spruce budworm, Choristoneura occidentalis (Lepidoptera: Tortricidae). Invert. Pathol. 18: 139-145. (PSW)

681. Thomas, H. A. 1971. Development of pales weevil larvae on an emulsified synthetic diet. USDA Forest Serv. Res. Note SE-163, 3 p. (SE)

682. Thomas, H. A. 1972. Feeding behaviour of the pales weevil. II. Response to some neutral lipid fractions of loblolly pine phloem. Can. Entomol. 104: 427-432. (SE)

683. Tumlinson, J. H., R. M. Silverstein, J. C. Moser, R. G. Brownlee, and J. M. Ruth. 1971. Identification of the trail pheromone of a leaf-cutting ant, Atta texana. Nature 234: 348-349. (SO)

684. Werner, R. A. 1972. Aggregation behaviour of the beetle Ips grandicollis in response to host-produced attractants. J. Insect Physiol. 18: 423-437. (SE)

Biological control of insects

685. Amman, G. D., and C. F. Speers. 1971. Introduction and evaluation of predators from India and Pakistan for control of the balsam woolly aphid (Homoptera: Adelgidae) in North Carolina. Can. Entomol. 103: 528-533. (SE)

686. Campbell, R. W., and J. D. Podgwaite. 1971. The disease complex of the gypsy moth. I. Major components. J. Invert. Pathol. 18: 101-107. (NE)

687. Dubois, N. R., and A. H. Squires. 1971. The determination of the relative virulence of Bacillus thuringiensis and related crystalliferous bacteria used against gypsy moth larvae (Porthetria (Lymantria) dispar (L.). Proc. IV Internatl. Coll. Insect Pathol., p. 196-208. (NE)

688. Fedde, G. F. 1971. A parasitic fungus disease of Adelges piceae (Homoptera: Phylloxeridae) in North Carolina. Ann. Entomol. Soc. Amer. 64: 749-750. (SE)

689. Hughes, K. M. 1972. The fine structure and development of two polyhedrosis viruses. J. Invert. Pathol. 19: 198-207. (PNW)

690. Kennedy, B. H., and J. R. Galford. 1971. Development of Dendrosoter protuberans (Nees) on larvae of Scolytus multistriatus (Marsham) reared on artificial medium. (Abstr). Proc. N. Cent. Br. Entomol. Soc. Amer. 26: 91. (NE)

691. Lewis, F. B. 1971. Mass propagation of insect viruses with specific reference to forest insects. Proc. IV Internat. Coll. Insect Pathol., p. 320-326. (NE)

692. Martignoni, M. E., P. J. Iwai, and J. P. Breillatt. 1971. Heterogeneous buoyant density in batches of viral nucleopolyhedra. J. Invert. Pathol. 18: 219-226. (PNW)

693. Mazzone, H. M. 1971. Cultivation of gypsy moth hemocytes. In Current Topics in Microbiology and Immunology 51: 196-200. (NE)

694. Mazzone, H. M., J. P. Breillatt, and N. G. Anderson. 1971. Zonal rotor purification and properties of a nuclear polyhedrosis virus of the European pine sawfly. Proc. IV Internatl. Coll. Insect Pathol., p. 371-379. (NE)

695. McKnight, M. E. 1971. Biology and habits of Bracon politiventris (Hymenoptera: Braconidae). Ann. Entomol. Soc. Amer. 64: 620-624. (RM)

696. Moore, G. E. 1972. Microflora from the alimentary tract of healthy southern pine beetles, Dendroctonus frontalis (Scolytidae), and their possible relationship to pathogenicity. J. Invert. Pathol. 19: 72-75. (SE)

697. Moore, G. E. 1972. Southern pine beetle mortality in North Carolina caused by parasites and predators. Environ. Entomol. 1: 58-65. (SE)

698. Moser, J. C., E. A. Cross, and L. M. Roton. 1971. Biology of Pyemotes parviscolyti. Entomophaga 16: 367-379. (SO)

699. Podgwaite, J. D., and R. W. Campbell. 1971. Disease in natural gypsy moth populations. Proc. IV Internatl. Coll. Insect Pathol., College Park, Md., p. 279-284. (NE)

700. Ryan, R. B., and R. D. Medley. 1971. Rearing insect parasitoids: a technique for counting, spacing, and holding lepidopterous pupae for parasitization. J. Econ. Entomol. 64: 1558. (PNW)

701. Ryan, R. B., and R. D. Medley. 1972. Interaction between two parasites, Apechthis ontario and Itoplectis quadricingulatus. 2. F_1 progeny production in light-stratified population cages. Ann. Entomol. Soc. Amer. 65: 172-177. (PNW)

702. Schmid, J. M. 1971. Medetera aldrichii (Diptera: Dolichopodidae) in the Black Hills II. Biology and densities of the immature stages. Can. Entomol. 103: 848-853. (RM)

703. Solomon, J. D., and R. C. Morris. 1971. Woodpeckers in the ecology of southern hardwood borers. In Ecol. Control of Anim. by Habitat Mgt. Tall Timbers Conf. Proc. 1970: 309-315. (SO)

704. Torgersen, T. R. 1971. Parasites of the western hemlock looper, Lambdina fiscellaria lugubrosa (Hulst), in southeast Alaska (Lepidoptera: Geometridae). Pan-Pac. Entomol. 47: 215-219. (PNW)

705. Townes, H., and T. R. Torgersen. 1972. Diagnostic features of the subfamilies of Ichneumonidae. Amer. Entomol. Inst., Ann Arbor, Mich., 3 p. (PNW)

Chemical control of insects

706. Barger, J. H., and R. A. Cuthbert. 1971. Statistical correlations between GLC assay and smaller European elm bark beetle bioassay. (Abstr.) Proc. N. Cent. Br. Entomol. Soc. Amer. 26: 93. (NE)

707. Barger, J. H., R. A. Cuthbert, and H. H. Roberto. 1971. Assessment of three pre-cold storage preparations on the feeding response of Scolytus multistriatus and the degradation of dicrotophos. J. Econ. Entomol 64: 621-624. (NE)

708. Beal, R. H. 1971. Concrete impregnated with chlordane or dieldrin not tubed over by subterranean termites. J. Econ. Entomol. 64: 1289-1291. (SO)

709. Beal, R. H., and V. K. Smith. 1971. Relative susceptibilities of Coptotermes formosanus, Reticulitermes flavipes, and R. virginicus to soil insecticides. J. Econ. Entomol. 64: 472-475. (SO)

710. Carter, F. L., C. A. Stringer, and D. Heinzelman. 1971. l-hydroxy-2, 3-epoxychlordene in Oregon soil previouly treated with technical heptachlor. Environ. Contam. & Toxicol. Bull. 6: 249-254. (SO)

711. DeBarr, G. L., and F. R. Matthews. 1971. Mist-blower applications for control of flower thrips and southern cone rust in a slash pine seed orchard. J. Econ. Entomol. 64: 520-522. (SE)

712. Hastings, F. L., and W. C. Dauterman. 1971. Phosphorylation and affinity constants for the inhibition of acetylcholinesterase by dimethoxon analogs. Pesticide Biochem. Physiol. 1: 248-255. (SE)

713. Holland, D. G. 1971. Evaluation of two insecticide bioassay techniques. (Abstr.) Proc. N. Cent. Br. Entomol. Soc. Amer. 26: 93. (NE)

714. Johnston, H. R., V. K. Smith, and R. H. Beal. 1971. Chemicals for subterranean termite control: results of long-term tests. J. Econ. Entomol. 64: 745-748. (SO)

715. Lyon, R. L. 1971. Contact toxicity of 17 insecticides applied topically to adult bark beetles. USDA Forest Serv. Res. Note PSW-249, 3 p. (PSW)

716. Lyon, R. L. 1971. Contact toxicity of 40 insecticides tested on pandora moth larvae. USDA Forest Serv. Res. Note PSW-235, 4 p. (PSW)

717. Lyon, R. L., and S. J. Brown. 1971. Contact toxicity of 14 insecticides tested on pine butterfly larvae. USDA Forest Serv. Res. Note PSW-257, 4 p. (PSW)

718. Lyon, R. L., and M. Page. 1971. Toxicity of insecticide aerosols to needle miner adults of the genus Coleotechnites. USDA Forest Serv. Res. Note PSW-243, 3 p. (PSW)

719. Lyon, R. L., and J. L. Robertson. 1971. Toxicity of stabilized and unstabilized pyrethrins applied to western spruce budworm. USDA Forest Serv. Res. Note PSW-255, 5 p. (PSW)

720. Maksymiuk, B. 1971. Aerial application of herbicides--problems and solutions. 20th Ann. Ore. Weed Conf. Proc., Salem, p. 25-27. (PNW)

721. Maksymiuk, B. 1971. How to minimize drift of pesticidal sprays. In Pesticides, pest control, and safety of forest and range lands. Eds. Joseph Capizzi and J. M. Witt, Ore. State Univ., Corvallis, p. 180-187. (PNW)

722. Maksymiuk, B. 1971. Kinetics and physics of pesticidal aerial sprays. In Pesticides, pest control, and safety of forest and range lands. Eds. Joseph Capizzi and J. M. Witt, Ore. State Univ., Corvallis, p. 171-179. (PNW)

723. Merkel, E. P., and G. L. DeBarr. 1971. Trunk implantations of dicrotophos for cone-insect control in slash pine seed production stands. J. Econ. Entomol. 64: 1295-1298. (SE)

724. Miskus, R. P., and T. L. Andrews. 1972. Stabilization of thin films of pyrethrins and allethrins. Agr. Food Chem. 20: 313. (PSW)

725. Roberts, R. B., R. L. Lyon, M. Page, and R. P. Miskus. 1971. Laser holography: its application to the study of the behavior of insecticide particles. J. Econ. Entomol. 2: 533-536. (PSW)

726. Robertson, J. L. 1972. Toxicity of Zectran to the California oakworm, a primary parasite, and a hyperparasite. Envir. Entomol. 1: 115-117. (PSW)

727. Schwartz (Robertson), J. L., and R. L. Lyon. 1971. Laboratory culture of orange tortrix and its susceptibility to four insecticides. Pyrethrum Post 11: 60-62. (PSW)

728. Tiernan, C., and R. P. Miskus. 1971. Toxicity of Zectran to western spruce budworm as a function of application site. J. Econ. Entomol. 64: 1307-1308. (PSW)

729. Van Haverbeke, D. F., R. E. Roselle, and G. D. Sexson. 1971. Western pine tip moth reduced in ponderosa pine shelterbelts by systemic insecticides. USDA Forest Serv. Res. Note RM-194, 8 p. (RM)

730. Werner, R. A. 1972. Systemic insecticidal action of disulfoton and Monitor in loblolly pine seedlings. J. Ga. Entomol. Soc. 7: 67-73. (SE)

731. Williams, C. B., Jr., and P. J. Shea. 1971. Insecticides. In Toward integrated control. 3rd Ann. NE Forest Insect. Work Conf. Proc. USDA Forest Serv. Res. Paper NE-194, p. 88-110. (NE)

732. Wilson, L. F., and P. C. Kennedy. 1971. Control of Saratoga spittlebug nymphs with systemic insecticides. J. Econ. Entomol. 64: 735-737. (NC)

Silvicultural and mechanical control of insects

733. Baker, B. H., G. D. Amman, and G. C. Trostle. 1971. Does the mountain pine beetle change hosts in mixed lodgepole and whitebark pine stands? USDA Forest Serv. Res. Note INT-151, 7 p. (INT)

734. Johnson, P. C. 1972. Bark beetle risk in mature ponderosa pine forests in western Montana. USDA Forest Serv. Res. Pap. INT-119, 32 p. (INT)

735. Sartwell, C. 1971. Thinning ponderosa pine to prevent outbreaks of mountain pine beetle. In Precommercial thinnings of coastal and intermountain forests in the Pacific Northwest. D. M. Baumgartner, ed., Wash. State Univ., Pullman, p. 41-52. (PNW)

Host resistance to insects and tree physiology

736. Ferrell, G. T. 1971. Host selection by the fir engraver, Scolytus ventralis (Coleoptera: Scolytidae): Preliminary field studies. Can. Entomol. 103: 1717-1725. (PSW)

737. Hodges, J. D., and P. L. Lorio, Jr. 1971. Comparison of field techniques for measuring moisture stress in large loblolly pines. Forest Sci. 17: 220-223. (SO)

738. Lorio, P. L., Jr., and J. D. Hodges. 1971. microrelief, soil water regime, and loblolly pine growth on a wet, mounded site. Soil Sci. Soc. Amer. Proc. 35: 795-800. (SO)

739. Smith, R. H. 1971. Xylem monoterpenes of Pinus ponderosa, P. washoensis, and P. jeffreyi in the Warner Mountains of California. Madrono 21: 26-32. (PSW)

740. Smith, R. H., and L. E. Green. 1971. Use of peak heights from a fast column for rapid approximation of the normalized monoterpene composition of pine resin. Jour. Chrom. Sci. (9): 755-756. (PSW)

741. Wright, J. W., and L. F. Wilson. 1972. Genetic differences in Scotch pine resistance to pine root collar weevil. Mich. State Univ. Res. Rep. 159, 5 p. (NC)

Insect sampling and survey methods

742. Aldrich, R. C., and W. J. Greentree. 1972. Microscale photo interpretation of forest and nonforest land classes. Fourth Annual Earth Resources Aircraft Program Review. NASA Manned Spacecraft Center, Houston, Texas. (PSW)

743. Amman, G. D., and S. Tunnock. 1971. Radiographic detection of Agathis pumila, a parasite of the larch casebearer. J. Econ. Entomol. 64: 1086-1088. (INT)

744. Dana, R. W., and R. J. Myhre. 1971. Calibration of color aerial photography. In Monitoring forest land from high altitude and from space. Sixth Ann. Prog. Rpt. Available in microfiche from NASA, Washington, D.C., Sci. and Tech. Aerospace Rpts. (PSW)

745. Greentree, W. J., and R. C. Aldrich. 1971. Multiseasonal film densities for automated forest and nonforest land classification. In Monitoring forest land from high altitude and from space. Sixth Ann. Prog. Rpt. Available in microfiche from NASA, Washington, D.C., Sci. and Tech. Aerospace Rpts. (PSW)

746. Heller, R. C., K. A. Zealer, and T. H. Waite. 1971. Trend and spread of bark beetle infestations from 1968 through 1971. In Monitoring forest land from high altitude and from space. Sixth Ann. Prog. Rpt. Available in microfiche from NASA, Washington, D.C., Sci. and Tech. Aerospace Rpts. (PSW)

747. Norick, N. X., and M. Wilkes. 1971. Classification of land use by automated procedures. In Monitoring forest land from high altitude and from space. Sixth Ann. Prog. Rpt. Available in microfiche from NASA, Washington, D.C., Sci. and Tech. Aerospace Rpts. (PSW)

748. Talerico, R. L. 1971. Fall cankerworm egg mass studies. J. Econ. Entomol. 64: 763-764. (NE)

749. Waite, T. H., R. C. Heller, and R. E. Stevens. 1971. Aerial photos determine optimum levels of stand density to reduce bark beetle infestations. In Monitoring forest land from high altitude and from space. Sixth Ann. Prog. Rpt. Available in microfiche from NASA, Washington, D.C., Sci. and Tech. Aerospace Rpts. (PSW)

750. Weber, F. P. 1971. The use of airborne spectrometers and multispectral scanners for previsual detection of ponderosa pine trees under stress from insects and diseases. In Monitoring forest land from high altitude and from space. Sixth Ann. Prog. Rpt. Available in microfiche from NASA, Washington, D.C., Sci. and Tech. Aerospace Rpts. (PSW)

751. Weber, F. P. 1972. Development and field test of an ERTS-matched four-channel spectrometer. Fourth Annual NASA-MSC Earth Resources Aircraft Program Review, NASA, Manned Spacecraft Center, Houston, Texas. (PSW)

752. Weber, F. P.,and R. C. Heller. 1971. Establishment of earth resources technology satellite test site in the Black Hills and identification of natural resolution targets. In Monitoring forest land from high altitude and from space. Sixth Ann. Prog. Rpt. Available in microfiche from NASA, Washington, D.C., Sci. and Tech. Aerospace Rpts. (PSW)

753. Wilson, L. F., and D. J. Gerrard. 1971. A new procedure for rapidly estimating European pine sawfly (Hymenoptera: Diprionidae) population levels in young pine plantations. Can. Entomol. 103: 1315-1322. (NC)

Forest pest management

754. Campbell, R. W. 1971. Introduction. In Towards Integrated Control. 3rd Ann. Northeastern Forest Insect Work Conf. Proc. USDA Forest Serv. Res. Pap. NE-194, p. 1. (NE)

755. Campbell, R. W. 1971. Developing a pest population management system. Tall Timber Conf. on Ecol. Animal Control by Habitat Mgt. Proc. 9-20. (NE)

756. Mitchell, R. G. 1971. Insects in the young stand of Douglas-fir and hemlock. Management of young growth Douglas-fir and western hemlock. Ore. State Univ., Symp. Proc. 1968, School Forest., pp. 47-71. (PNW)

757. Waters, W. E. 1971. Ecological management of forest insect populations. In Ecological Animal Control by Habitat Management. Proc. Tall Timber Conf., p. 141-153. (WO)

FOREST ENGINEERING RESEARCH

Improving engineering systems

758. Arola, Rodger, A. 1972. Estimating force and power requirements for crosscut shearing of roundwood. USDA Forest Serv. Res. Pap. NC-73, 8 p. (NC)[1]

759. Biller, C. J. 1971. Are your log skidder tires too small and underinflated? Forest Indus. 98(13): 34-37. (NE)

760. Biller, C. J. 1971. Prediction of skidder tire wear in Appalachia. Trans. ASAE 14(2): 350-353. (NE)

761. Biller, C. J., and R. L. Hartman. 1971. Tractive characteristics of wheeled-skidder tires. Trans. ASAE 14(6): 1024-1026. (NE)

762. Bolinger, J. W., K. C. Elliott, and A. D. Longhouse. 1971. Monitoring cyclic power demands of a diesel engine. W. Va. Univ. Agric. Exp. Station, Morgantown, W. Va., 54 p. (NE)

763. Carson, Ward W. 1971. Lateral excursions of running skylines used in selective cutting. Symp. on Forest Operations in Mountainous Regions, Krasnodar, U.S.S.R., 21 p. (PNW)

764. Carson, Ward W., and Charles N. Mann. 1971. An analysis of running skyline load path. USDA Forest Serv. Res. Pap. PNW-120, 9 p. (PNW)

765. Carson, Ward W., and Penn A. Peters. 1971. Gross static lifting capacity of logging balloons. USDA Forest Serv. Res. Note PNW-152, 17 p. (PNW)

766. Carson, Ward W., Donald D. Studier, and Hilton H. Lysons. 1971. Running skyline design with a desk-top computer/plotter. USDA Forest Serv. Res. Note PNW-153, 21 p. (PNW)

767. Chappel, T. W., and T. A. Harrington. 1971. Mechanized gum harvesting. Naval Stores Rev. 81(9): 4-5, 13. (SO)

768. Chappell, T. W., and H. T. Taylor, Jr. 1971. Limited evaluation of a mechanized pulpwood harvesting system. Trans. ASAE 14: 343-345. (SO)

769. Erickson, John R. 1971. Bark-chip segregation: A key to whole tree utilization. Forest Prod. J. 21(9): 111-113. (NC)

770. Gardner, R. B. 1971. Forest road standards as related to economics and the environment. USDA Forest Serv. Res. Note INT-145, 4 p. (INT)

771. Gardner, R. B. 1971. How can Inland Empire timber be used? Western Conserv. J. XXVIII(2): 28-30. (INT)

772. Gibson, H. G., and C. J. Biller. 1971. Side-slope stability of logging tractors and forwarders. ASAE Pap. No. 71-611, Winter Mtg., Chicago, Ill., 19 p. (NE)

773. Gibson, H. G., K. C. Elliott, and S. P. E. Persson. 1971. Side-slope stability of articulated-frame logging tractors. J. Terramechanics 8(2): 65-79. (NE)

774. Gonsoir, M. J., and R. B. Gardner. Investigation of slope failures in the Idaho Batholith. USDA Forest Serv. Res. Pap. INT-97, 34 p. (INT)

775. Gow, John L., and W. A. Hunt. 1971. The hydraulic transport of wood chips. Engineering Research Laboratories,

[1] This publication begins the list for Forest Engineering Research

Endowment & Research Foundation, Montana State University, Aug. 1971, 106 p. (INT)

776. Hartman, R. L., and H. G. Gibson. 1971. Techniques for the wheeled-skidder operator. South. Lumberman 222(2760): 89-90, 92, 94, 96-98. (NE)

777. Hudson, Larry E. 1971. Segregation of aspen wood chips from bark chips by the Cartesian diver principle. M.S. thesis, Mich. Tech. Univ., 99 p. (NC)

778. Julien, Larry M., John C. Edgar, and Terrence M. Conder. 1971. A density-gradient technique for obtaining wood and bark chip density. USDA Forest Serv. Res. Note NC-112, 4 p. (NC)

779. Lysons, Hilton H. 1971. Cable logging in tomorrow's forest environment. Symp. on Forest Operations in Mountainous Regions, Krasnodar, U.S.S.R., 25 p. (PNW)

780. Mann, Charles N. 1971. Balloon-running skyline system. Symp. on Forest Operations in Mountainous Regions, Krasnodar, U.S.S.R., 12 p. (PNW)

781. Phillips, R. A., and C. J. Biller. 1971. A meter/recorder to measure logging road roughness--progress report. Field Notes, Engin. Tech. Inform. System, USDA Forest Serv. 3(9): 8-10. (NE)

782. Richardson, B. Y. 1971. Trafficability tests of an articulated log skidder. Forest Prod. J. 21(1): 31-33. (SO)

783. Schillings, P. L., and T. W. Chappell. 1971. New orientation of Forest Service engineering project at Auburn University. Tenth Auburn Forestry Forum Proc., p. 33-38. (SO)

784. Sturos, John A. 1972. Determining the terminal velocity of wood and bark chips. USDA Forest Serv. Res. Note NC-131, 4 p. (NC)

785. Wehr, Michael A. 1971. Design of a prototype compression debarker. M.S. thesis, Mich. Tech. Univ., 52 p. (NC)

FOREST PRODUCTS UTILIZATION RESEARCH

Wood and timber quality

786. Burgan, Robert E., W. H. C. Wong, Jr., R. G. Skolmen, and H. L. Wick. 1971. Guide to log defect indicators in koa ohia...preliminary rules for volume deductions. USDA Forest Serv. unnumbered paper, 4 p. (PSW)[1]

787. Brisbin, Robert L., and David L. Sonderman. 1971. Tree grades for eastern white pine. USDA Forest Serv. Res. Pap. NE-214, 30 p. (NE)

788. Gammon, Glenn L. 1971. Volume loss and grade change of hardwood lumber during air-drying. USDA Forest Serv. Res. Pap. NE-227, 16 p. (NE)

789. Gedney, Donald R., and John W. Henley. 1971. Utilization estimates for western softwoods--trees, logs, and residue. USDA Forest Serv. Res. Note PNW-158, 8 p. (PNW)

790. Galiger, L., and H. Hallock. 1971. Computer program for grading hardwood lumber. USDA Forest Serv. unnumbered paper, 99 p. (FPL)

791. Hallock, H., and L. Galiger. 1971. Grading hardwood lumber by computer. USDA Forest Serv. Res. Pap. FPL-157, 15 p. (FPL)

792. Hallock, H., and D. Lewis. 1971. Increasing softwood dimension yield from small logs--Best Opening Face. USDA Forest Serv. Res. Pap. FPL-166, 11 p. (FPL)

[1] This publication begins the list for Forest Products Utilization Research.

793. Hallock, Hiram, and F. B. Malcolm. 1972. Sawing to reduce warp in plantation red pine studs. USDA Forest Serv. Res. Pap. FPL-164, 26 p. (FPL)

794. Hanks, Leland F. 1971. Interim hardwood tree grades for factory lumber. USDA Forest Serv. Res. Pap. NE-199, 29 p. (NE)

795. Koeppen, R. C. 1972. Charcoal identification. USDA Forest Serv. Res. Note FPL-0217, 3 p. (FPL)

796. Lane, Paul H. 1971. Identifying veneer in recovery studies. Forest Prod. J. 21(6), 2 p. (PNW)

797. McGinnes, E. A., Jr., C. Chang, and K.Y. Wu. 1971. Ring shake in some hardwood species--the individual tree approach. J. Polymer Sci., Part C, No. 36: 153-176. (NE)

798. Malcolm, F. B. 1971. Symmetrically placed expansion slots solve problems of screaming saws. Forest Industries. 98(6): 76-77. (FPL)

799. Murmanis, L. 1971. Particles and microtubules in vascular cells of Pinus strobus L. during cell wall formation. New Phytol. 70: 1089-1093. (FPL)

800. Murmanis, L. 1971. Structural changes in the vascular cambium of Pinus strobus L. during an annual cycle. Ann. Bot, 35: 133-141. (FPL)

801. Ostrander, M. D. 1971. Identification and evaluation of defects in eastern white pine logs and trees. USDA Forest Serv. Res. Pap. NE-190, 27 p. (NE)

802. Ostrander, Myron D., and Robert L. Brisbin. 1971. Sawlog grades for eastern white pine. USDA Forest Serv. Res. Pap. NE-205, 25 p. (NE)

803. Pong, W. Y. 1971. Changes in grade and volume of central California white fir lumber during drying and surfacing. USDA Forest Serv. Res. Note PNW-156, 20 p. (PNW)

804. Pong, W. Y., and G. H. Jackson. 1971. Diagraming surface characteristics of true fir logs. USDA Forest Serv. unnumbered paper, 7 p. (PNW)

805. Pronin, D. 1971. Estimating tree specific gravity of major pulpwood species of Wisconsin. USDA Forest Serv. Res. Pap. FPL-161, 16 p. (FPL)

806. Ross, William D., and Robert L. Krahmer. 1971. Some sources of variation in structural characteristics of Douglas-fir bark. Wood and Fiber 3(1): 35-46. (PNW)

807. Saucier, Joseph R. 1972. Wood specific gravity of eleven species of pine. Forest Prod. J. 22(3): 32-33. (SE)

808. Saucier, J. R., and Albert F. Ike. 1972. Growth and wood properties response of American sycamore to fertilization and thinning. Proc. of Symp. on Effect of Growth Acceleration on Wood Properties, Nov. 10-11, 1971, 12 p. (SE)

809. Schumann, D. R. 1972. Dimension yields from alder lumber. USDA Forest Serv. Res. Pap. FPL-170, 12 p. (FPL)

810. Schumann, D. R. 1971. Dimension yields from black walnut lumber. USDA Forest Serv. Res. Pap. FPL-162, 15 p. (FPL)

811. Schroeder, James G., and Douglas R. Phillips. 1972. Seasonal moisture content of loblolly and slash pine trees. Forest Prod. J. 22(4): 54-56. (SE)

812. Smith, D. M., H. E. Wahlgren, and G. W. Bengtson. 1972. Effect of irrigation and fertilization on the wood quality of young slash pine. Proc. of Symp. on Effect of Growth Acceleration on Wood Properties, Nov. 10-11, 1971, 14 p. (FPL)

813. Wilcox, Wayne W., and Nancy D. Oldham. 1972. Bacterium associated with wetwood in white fir. Phytopathology 62: 384-385. (PNW)

814. Wilcox, Wayne E., and Clemens G. R. Schlink. 1971. Absorptivity and pit structure as related to wetwood in white fir. Wood and Fiber 2(4): 373-379. (PNW)

815. Woodfin, Richard O., Jr., and Paul H. Lane. 1971. Veneer yield by log grade and size from Black Hills ponderosa pine. USDA Forest Serv. Res. Note PNW-164, 7 p. (PNW)

816. Yerkes, Vern P., and Richard O. Woodfin, Jr. 1972. Veneer recovery from Black Hills ponderosa pine. USDA Forest Serv. Res. Pap. RM-82, 23 p. (RM)

Wood products and wood processing

817. Anonymous. 1972. Kiln schedules for foreign woods. USDA Forest Serv. Forest Prod. Tech. Rept. No. 2, 5 p. (FPL)

818. Barger, Roland L., and Peter F. Ffolliott. 1971. Effects of extractives on specific gravity of southwestern ponderosa pine. USDA Forest Serv. Res. Note RM-205, 4 p. (RM)

819. Barger, Roland L., and Peter F. Ffolliott. 1971. New approach to estimating timber products. Progr. Agr. Ariz. 23(3): 11-13. (RM)

820. Barger, Roland L., and Peter F. Ffolliott. 1971. Prospects for cottonwood utilization in Arizona. Progr. Agr. Ariz. 23(3): 14-16. (RM)

821. Beall, F. C. 1971. Differential calorimetric analysis of wood and wood components. Wood Sci. and Technol. 5: 159-175. (FPL)

822. Black, John M. 1971. Finishes, construction factors, and design to compensate for the effects of weather on wood surfaces. Background pap. WCH/71/4a/4, World Consultation on the Use of Wood in Housing, UN Centre for Housing, Building and Planning, UN Ind. Develop, Organ. and Forest Dept of FAO, 12 p. (FPL)

823. Blew, J. O., and H. L. Davidson. 1971. Preservative retentions and penetration in the treatment of white fir. Amer. Wood Preserv. Assoc. Proc. 67: 204-221. (FPL)

824. Brenden, J. J. 1971. Usefulness of a new method for measuring smoke yield from wood species and panel products. Forest Prod. J. 21(12): 22-28. (FPL)

825. Chudnoff, M. 1971. Tissue regeneration of debarked eucalypts. Forest Sci. 17(3): 300-305. (ITF)

826. Chudnoff, M., and E. Goytia. 1971. Treatability of Puerto Rican woods. USDA Forest Serv. Res. Pap. ITF-11, 8 p. (ITF)

827. Cooper, Glenn A. 1971. Black walnut extractives availability is influenced by thawing-to-extraction time. Forest Prod. J. 21(10): 44-45. (NC)

828. Cooper, Glenn A., and Stanley H. Barham. 1972. Prefreezing effects on three hardwoods. Forest Prod. J. 22(2): 24-25. (NC)

829. Dunmire, D. E., E. F. Landt, and R. E. Bodkin. 1972. Logging residue is a source of valuable black walnut dimension. Forest Prod. J. 22(1): 13-17. (NC)

830. Ffolliott, Peter F., Frederic R. Larson, and Roland L. Barger. 1971. Predicting scaled volume recoverable from cutover southwestern ponderosa pine stands. USDA Forest Serv. Res. Note RM-195, 8 p. (RM)

831. Gatchell, Charles J., and Edwin L. Lucas. 1971. Machine driving of wooden and steel highway guardrail posts under adverse conditions. USDA Forest Serv. Res. Pap. NE-212, 19 p. (NE)

832. Gjovik, L. R., B. A. Bendtsen, and H. G. Roth. 1972. Condition of preservative-treated cooling tower slats after 10-year service. Forest Prod. J. 22(4): 35-40. (FPL)

833. Gjovik, L. R., and H. L. Davidson. 1971. Comparison of wood preservatives in Mississippi post study. USDA Forest Serv. Res. Note FPL-01, 17 p. (FPL)

834. Gjovik, L. R., and H. L. Davidson. 1971. Comparison of wood preservatives in stake tests. USDA Forest Serv. Res. Note FPL-02, 90 p. (FPL)

835. Hart, C. A., and W. M. Darwin. 1971. The slow drying rate of white oak. Wood Sci. 4(1): 46-54. (FPL)

836. Heidt, Jack D., Donald A. Jameson, Roland L. Barger, and Bernard J. Erickson. 1971. Determining timber conversion alternatives through computer analysis. USDA Forest Serv. Res. Pap. RM-74, 27 p. (RM)

837. Holmes, C. A. 1972. Methods of evaluating fire-retardant treatment for wood shingles. Forest Prod. J. 22(3): 45-50. (FPL)

838. Holmes, C. A. 1971. Evaluation of fire-retardant treatments for wood shingles. USDA Forest Serv. Res. Pap. FPL-158, 26 p. (FPL)

839. Howard, E. T. 1971. Bark structure of the southern pines. Wood Sci. 3: 134-148. (SO)

840. Hse, C. Y. 1971. Properties of phenolic adhesives as related to bond quality in southern pine plywood. Forest Prod. J. 21(1): 44-52. (SO)

841. Koch, P. 1971. Force and work to shear green southern pine logs at slow speed. Forest Prod. J. 21(3): 21-26. (SO)

842. Koch, P. 1971. One-day kilning dries pine studs to 10 percent moisture. Forest Industries 98(12): 70-71. (SO)

843. Koch, P. 1971. Process for straightening and drying southern pine 2 by 4's in 24 hours. Forest Prod. J. 21(5): 17-24. (SO)

844. Koch, P. 1971. Process of making laminated wood product utilizing modulus of elasticity measurement. (U.S. Pat. No. 3,580,760) U.S. Pat. Off., Washington, D.C., 3 p. (SO)

845. Koch, P. 1971. Technological developments in the southern pine industry. Forest Farmer 30(7): 16-20. (SO)

846. Koch, P., and J. F. Mullen. 1971. Bark from southern pine may find use as fuel. Forest Industries 98(4): 36-37. (SO)

847. Landt, Eugene F. 1971. Durable outdoor benches made of red oak and hickory. South. Lumberman 223(2776): 143-145. (NC)

848. Lemoine, T. J., and P. Koch. 1971. Steam-bending properties of southern pine. Forest Prod. J. 21(4): 34-42. (SO)

849. Lowery D. P. 1971. Measurement of vapor pressure generated in wood during drying. Wood Sci. 3(4): 218-219. (INT)

850. Lowery, D. P. 1971. Vapor pressures generated in drying Engelmann spruce wood. Proc. Western Dry Kiln Clubs, 22d Ann. Mtg., p. 25-29. (INT)

851. Lowery, D. P., J. P. Krier, and J. R. Host. 1971. Bark residues in Western Montana. USDA Forest Serv. Res. Note INT-140, 4 p. (INT)

852. McMillin, C. W., and J. E. Harry. 1971. Laser machining of southern pine. Forest Prod. J. 21(10): 34-37. (SO)

853. Michie, Jarvis D., Charles J. Gatchell, and Theodore J. Duke. 1971. Dynamic evaluation of timber posts for highway guardrails. Design of Traffic Safety Barriers, Highway Res. Record No. 343. Highway Res. Board, Natl. Acad. of Sci., p. 19-33. (NE)

854. Mueller, Lincoln A., Donald C. Markstrom, and Roland L. Barger. 1971. Moisture content of laminated beams in use in the Rocky Mountain area. USDA Forest Serv. Res. Pap. RM-73, 8 p. (RM)

855. Murphey, W. K., B. E. Cutter, E. Wachsmuth, and C. J. Gatchell. 1971. Feasibility studies on gluing red oak at elevated moisture contents. Forest Prod. J. 21(8): 56-59. (NE)

856. Peters, C., and A. Mergen. 1971. Measuring wood surface smoothness: A proposed method. Forest Prod. J. 21(7): 28-30. (FPL)

857. Reynolds, Hugh W. 1971. Manufacture of industrial products from oak. Oak Symp. Proc. USDA Forest Serv., Northeastern Forest Exp. Station, Upper Darby, Pa., p. 103-105. (NE)

858. Reynolds, Hugh W., and Charles J. Gatchell. 1971. Think twice, cut once to profit from low-grade logs. Wood & Wood Prod. 76(9), 4 p. (NE)

859. Rietz, R. C., and R. H. Page. 1971. Air drying of lumber. Forest Serv., USDA Agr. Handb. 402, 110 p. (FPL)

860. Rosen, Howard N., and Hugh M. Hulburt. 1971. Continuous vacuum crystallization of potassium sulfate. Chem. Engin. Symp. Ser. No. 110, 67: 18-26. (NC)

861. Rosen, Howard N., and Hugh M. Hulburt. 1971. Growth rate of potassium sulfate in a fluidized-bed crystallizer. Chem. Engin. Symp. Ser. No. 110, 67: 27-31. (NC)

862. Simpson, W. T. 1971. Equilibrium moisture content prediction for wood. Forest Prod. J. 21(5): 48-49. (FPL)

863. Simpson, W. T. 1971. Moisture changes induced in red oak by transverse stress. Wood and Fiber 3(1): 13-21. (FPL)

864. Skolmen, R. G. 1971. A durability test of wood posts in Hawaii... Third Progress Report. USDA Forest Serv. Res. Note PSW-260, 4 p. (PSW)

865. Skolmen, R. C. 1971. Processing Hawaii-grown robusta eucalyptus logs into furniture. Economic Dev. Administration Technical Project, U.S. Dept. of Commerce. USDA Forest Serv. unnumbered paper, 15 p. (PSW)

866. Stewart, Harold A. 1972. Abrasive vs. knife planing. South. Lumberman 224(2779): 13-18. (NC)

867. Stewart, Harold A. 1971. Chip formation when orthogonally cutting wood against the grain. Wood Sci. 3(4): 193-203. (NC)

868. Stewart, Harold A. 1971. Cross-grain knife planing improves surface quality and utilization of aspen. USDA Forest Serv. Res. Note NC-127, 4 p. (NC)

869. Stewart, Harold A. 1971. Chips produced with a helical cutter. Forest Prod. J. 21(5): 44-45. (NC)

870. Stewart, Harold A. 1971. Rake angle for planing hard maple determined best by depth of chipped grain. USDA Forest Serv. Res. Note NC-116, 4 p. (NC)

871. USDA, Forest Service. 1970. Blistering, peeling, and cracking of house paints from moisture. USDA Forest Serv. Res. Note FPL-0125, 7 p. (FPL)

872. USDA, Forest Service. 1971. Unclaimed profits in black walnut. USDA Forest Serv. Leaflet NC-15, 4 p. (NC)

873. Wengert, E. M. 1971. Dry kiln automation. South. Lumberman 223(2776): 123-124. (FPL)

874. Wengert, E. M. 1971. Improvements in solar dry kiln design. USDA Forest Serv. Res. Note FPL-0212. (FPL)

875. Wengert, E. M., and R. C. Baltes. 1971. Accelerating oak drying by presurfacing, accelerated schedules, and kiln automation. USDA Forest Serv. Res. Note FPL-0214. (FPL)

Wood chemistry and fiber products

876. Auchter, R. J. 1971. Future wood needs for papermaking fibers should not be a problem. Paper Trade J. 155(34): 58-61. (FPL)

877. Benson, Roy E. 1971. Effects of relative humidity and temperature on tensile stress-strain properties of kraft linerboard. Tappi 54(5): 699-703. (FPL)

878. Byrd, Von L. 1972. Effect of relative humidity changes during creep on handsheet paper properties. Tappi 55(2): 247-252. (FPL)

879. Byrd, Von L. 1971. The effect of humidity on paper. Chem 26, 7(11): 30-35. (FPL)

880. Carr, W. F. 1971. Many problems involved in increasing utilization of waste paper. Pap. Trade J. 155(20): 48-52. (FPL)

881. Caulfield, D. F., and R. A. Steffes. 1971. Correcting absorption errors in X-ray fluorescence analyses of preservative-treated wood. Wood Sci. 4(2): 106-113. (FPL)

882. Chang, T. L., T. E. Mead, and D. F. Zinkel. 1971. Mass spectra of diterpene resin acid methyl esters. J. Amer. Oil Chem. Soc. 48: 455-461. (FPL)

883. Connors, W. J., J. S. Ayers, K. V. Sarkanen, and J. S. Gratzel. 1971. Demethylation and ortho-quinone formation in enzymic dehydrogenation of lignin model phenols. Tappi 54(8): 1284-1288. (FPL)

884. Fahey, D. J., and D. S. Pierce. 1971. Resistance of resin-impregnated paper overlays to accelerated weathering. Forest Prod. J. 21(11): 30-38. (FPL)

885. Feist, W. C., W. E. Eslyn, E. L. Springer, and G. J. Hajny. 1971. Determining loss of wood substance after fungal attack--A comparison of two methods. Tappi 54(8): 1271-1273. (FPL)

886. Feist, W. C., E. L. Springer, and G. J. Hajny. 1971. Encasing wood chip piles in plastic membranes to control chip deterioration. Tappi 54(7): 1140-1142. (FPL)

887. Feist, W. C., E. L. Springer, and G. J. Hajny. 1971. Viability of parenchyma cells in stored green wood. Tappi 54(8): 1295-1297. (FPL)

888. Harkin, J. M. 1971. Bark and its possible uses. USDA Forest Serv. Res. Note FPL-091, 56 p. (FPL)

889. Kratochvil, J. F., R. F. Burris, M. K. Seikel, and J. M. Harkin. 1971. Isolation and characterization of α-guaiaconic acid. Phytochemistry 10(10): 2529-2531. (FPL)

890. Mellenberger, R. W., L. D. Satter, M. A. Millett, and A. J. Baker. 1971. Digestion of aspen, alkali-treated aspen, and aspen bark by goats. J. Animal Sci. 32(4): 756-763. (FPL)

891. Minor, J. L., and N. Sanyer. 1971. Oxygen/alkali oxidation of cellulose and model alcohols and inhibition by iodide. J. Polymer Sci. 36: 73-84. (FPL)

892. Mohaupt, A. A., and J. W. Koning, Jr. 1971. A practical method for recycling wax-treated corrugated. Boxboard Containers 79(6): 60-62. (FPL)

893. Myers, G. C. 1971. Household separation of wastepaper: FPL employee survey. USDA Forest Serv. Res. Pap. FPL-159, 11 p. (FPL)

894. Myers, G. C. 1971. What's in the wastepaper fiber collected from municipal trash. Pap. Trade J. 155(35): 32-35. (FPL)

895. Nagasampagi, B. A., and J. W. Rowe. 1971. Sterols of coffee. Phytochemistry 10: 1101-1107. (FPL)

896. Rowe, J. W., B. A. Nagasampagi, A. W. Burgstahler, and J. W. Fitzsimmons. 1971. Derivatives of nordehydroabietane from pine bark. Phytochemistry 10: 1647-1651. (FPL)

897. Rowe, J. W., R. C. Ronald, and B. A. Nagasampagi. 1972. Terpenoids of lodgepole pine bark. Phytochemistry 11: 365-369. (FPL)

898. Rowell, R. M. 1971. Oxidative alkaline degradation. III. Stopping reaction. Proc. Can. Pulp and Pap. Assoc. 72(7): T236-T239. (FPL)

899. Rowell, R. M., J. Green, and M. A. Daugherty. 1971. Alkaline degradation of cellobiose with kraft green liquor. USDA Forest Serv. Res. Pap. FPL-153, 8 p. (FPL)

900. Seikel, M. K., F. D. Hostettler, and G. J. Niemann. 1971. Phenolics of Quercus rubra wood. Phytochemistry 10: 2249-2251. (FPL)

901. Seshadri, T. R., and T. N. C. Vadanthan. 1971. Chemical examination of the barks and heartwoods of betula species of American origin. Phytochemistry 10: 897. (FPL)

902. Spalding, B. P., D. F. Zinkel, and D. R. Roberts. 1971. New labdane resin acids from Pinus elliottii. Phytochemistry 10: 3289-3292. (FPL)

903. Springer, E. L., G. J. Hajny, and W. C. Feist. 1971. Spontaneous heating in piled wood chips. II. Effect of temperature. Tappi 54(4): 589-591. (FPL)

904. Springer, E. L., E. J. Haslerud, D. M. Fries, I. T. Clark, G. J. Hajny, and L. L. Zoch. 1971. An evaluation of four chemicals for preserving wood chips stored outdoors. Tappi 54(4): 555-560. (FPL)

905. Springer, E. L., and L. L. Zoch. 1971. Delignifying aspen wood with aqueous xylenesulfonic acid at 100° C. Tappi 54(12): 2059-2060. (FPL)

906. Steinmetz, P. E., and D. J. Fahey. 1971. Effect of manufacturing variables on stability and strength of wet-formed hardboards. USDA Forest Serv. Res. Pap. FPL-142, 7 p. (FPL)

907. Stockmann, Volker E. 1971. Effect of pulping on cellulose structure. Part I. A hypothesis of transformation of fibrils. Tappi 54(12): 2033-2037. (FPL)

908. Stockmann, Volker E. 1971. Effect of pulping on cellulose structure. Part II. Fibrils contract longitudinally. Tappi 54(12): 2038-2045. (FPL)

909. Stockmann, Volker E. 1971. Elementary cellulose fibrils possess an entropic deformation mechanism. J. Polymer Sci., Pt. C., Polymer Symposia, No. 36: 363-381. (FPL)

910. Weatherwax, R. C., and D. F. Caulfield. 1971. Cellulose aerogels: An improved method for preparing a highly expanded form of dry cellulose. Tappi 54(6): 985-986. (FPL)

911. Zinkel, D. F., and B. P. Spalding. 1972. Anticopalic acid in Pinus strobus and Pinus monticola. Phytochemistry 11: 425-426. (FPL)

912. Zinkel, D. F., and B. P. Spalding. 1971. Strobic acid, a new resin acid from Pinus strobus. Tetrahedron Lett. No. 27: 2459-2462. (FPL)

913. Zinkel, D. F., J. K. Toda, and J. W. Rowe. 1971. Occurrence of anti-copalic acid in Pinus monticola. Phytochemistry 10: 1161-1163. (FPL)

914. Zinkel, D. F., L. C. Zank, and M. F. Wesolowski. 1971. Diterpene resin acids: A compilation of infrared, mass, nuclear magnetic resonance, ultraviolet spectra, and gas chromatographic retention data (of the methyl esters). USDA Forest Serv., unnumbered paper, 191 p. (FPL)

Wood engineering

915. Anderson, L. O., T. B. Heebink, and A. E. Oviatt. 1971. Construction guides for exposed wood decks. USDA Forest Serv. Pac. Northwest For. and Range Exp. Sta. unnumbered publ., 78 p. (PNW)

916. Anonymous. 1971. Predicting damping in wood structures. Forest Prod. J. 22(2): 59-60. (PNW)

917. Bendtsen, B. A., and R. L. Ethington. 1972. Southern wood density survey. Important structural properties and specific gravity of loblolly, longleaf, shortleaf, and slash pines. USDA Forest Serv. Res. Pap. FPL-156, 14 p. (FPL)

918. Blomquist, R. F. 1971. Applications and evaluation of adhesives. Two chapters in "Adhesion and Bonding," edited by N. M. Bikales. Wiley-Interscience, New York, p. 99-113. (SE)

919. Bohannan, Billy, et al. 1971. Panel discussion--glued laminated timber--a reliable engineering material. AREA Bull. 633 Proc.: 72, 7 p. (FPL)

920. Bohannan, Billy. 1970. Nu-Frame systems and low-cost house plans. Natl. Housing Conf. Proc. Ext. Workers. Nov. 16-20, 1970, sponsored by State and Federal Ext. Services, 9 p. (FPL)

921. Ethington, R. L. 1972. Is wood hardness affected by preservative treatment? Forest Prod. J. 22(5): 60-61. (FPL)

922. Forest Products Laboratory. 1971. Wood pallet manufacturing. USDA Forest Serv. Res. Note FPL-0213, 37 p. (FPL)

923. Gaby, L. I. 1971. Longitudinal shrinkage and fibril angle variation in corewood of southern pine. Ga. Forest Res. Council Res. Pap. 70, 5 p. (SE)

924. Gaby, L. I. 1971. Pine and hardwood hitch up for siding. South. Lumberman 223(2776): 120-122. (SE)

925. Godshall, W. D. 1971. Frequency response, damping, and transmissibility characteristics of top-loaded corrugated containers. USDA Forest Serv. Res. Pap. FPL-160, 12 p. (FPL)

926. Grantham, John B. 1971. Airborne-noise control in lightweight floor-ceiling systems. Sound & Vibration 5(6): 12-16. (PNW)

927. Heebink, T. B., and J. B. Grantham. 1971. Field-laboratory STC ratings of wood-framed partitions. Sound & Vibration 5(10): 12-16. (PNW)

928. Jenkinson, Paul M., and John J. Zahn. 1972. Lateral stability of beam-and-deck structure. J. Struct. Div. ASCE, 20 p. (FPL)

929. Jordan, C. A. 1971. Testing of cushioned loads. Mod. Packaging 44(7): 59-60, 62, 66. (FPL)

930. Kinney, E. F. 1972. Build your own enclosure for package tests. Package Engin. 17(1): 66-68. (FPL)

931. Koning, J. W., Jr., and W. D. Godshall. 1971. Method for recording machine speed at which corrugating medium is fluted. USDA Forest Serv. Res. Note FPL-0216, 6 p. (FPL)

932. Koning, J. W., Jr., and R. C. Moody. 1971. Predicting flexural stiffness of corrugated fiberboard. Tappi 54(11): 1879-1881. (FPL)

933. Lewis, Wayne C. 1971. Simulated service testing of wood and woodbase finish flooring. USDA Forest Serv. Res. Note FPL-0215, 20 p. (FPL)

934. Lewis, Wayne C. 1970. Country statement for United States of America for third session FAO Committee on Wood-Based Panel Products. FOI: WPP/70/ Country Statements, Rome, Italy. Nov., 10 p. (FPL)

935. Lewis, Wayne C. 1971. Board materials from wood residues. USDA Forest Serv. Res. Note FPL-045 (Rev.), 11 p. (FPL)

936. Lewis, Wayne C. 1971. Use of panel products in housing. Background Pap. WCH/71/3/2, World Consultation on the Use of Wood for Housing, UN Centre for Housing, Building, and Planning, UN Indus. Develop. Organ. and Forest. Dept. of FAO of UN. July, 13 p. (FPL)

937. Lewis, W. C., and B. G. Heebink. 1971. Reconstituted products from oak. Oak Symp. Proc., USDA Forest Serv., NE Forest Exp. Station, Upper Darby, Pa., p. 106-110. (FPL)

938. Moody, R. C., and Billy Bohannan. 1971. Flexural properties of glued-laminated southern pine beams--finger joint and specific gravity effects. USDA Forest Serv. Res. Pap. FPL-151, 36 p. (FPL)

939. Oviatt, A. E. 1972. Moisture in wood structures for ice skating. Forest Prod. J. 22(3): 50-54. (PNW)

940. Stern, R. K. 1971. How variations in corrugated-pad composition affect cushioning. Package Engin. 16(7): 50-53. (FPL)

941. Tuomi, Roger, and Billy Bohannan. 1971. Timber bridges go mod. Wood Preserv. 49(12), 6 p. (FPL)

942. Vick, C. B. 1971. Elastomeric adhesives for field-gluing plywood floors. Forest Prod. J. 21(8): 34-42. (SE)

943. Vick, C. B., and D. C. Wittenberg. 1971. Wind resistance of stressed-skin curtain-wall panels bonded with elastomeric adhesives. USDA Forest Serv. Res. Pap. SE-81, 11 p. (SE)

944. Western Wood Products Association. 1971. Sound control. Insert for SWEETS catalog, 8 p. (PNW)

945. Wilkinson, Thomas Lee. 1971. Theoretical lateral resistance of nailed joints. J. Struct. Div. ASCE, 18 p. (FPL)

946. Wilkinson, Thomas Lee. 1971. Bearing strength of wood under embedment loading of fasteners. USDA Forest Serv. Res. Pap. FPL-163, 12 p. (FPL)

947. Wittenberg, D. C. 1971. A hexagonal home of wood (Plan FS-SE-8). Plans, specifications, and materials list. USDA Forest Serv., 12 p. (SE)

948. Zahn, John J. Shear stiffness of 2-inch wood decks for roof systems. USDA Forest Serv. Res. Pap. FPL-155, 20 p. (FPL)

949. Zornig, H. F. 1971. A hillside home (Plan FS-SE-9). Plans, specifications, materials list, construction notes, and cost estimates. USDA Forest Serv., 8 p. (SE)

950. Zornig, H. F. 1971. A round home of wood (Plan FS-SE-7). Plans, specifications, and materials list. USDA Forest Serv., 10 p. (SE)

951. Zornig, H. F. 1971. Wood homes help improve the quality of life. Fla. Architect 21(3): 18-19. (SE)

Miscellaneous

952. Fleischer, H. O. 1971. Wood housing: A worldwide look. Woodworking & Furn. Digest 73(10): 28-30 (also Forest Prod. J. 21(12): 12-13). (FPL)

953. Fleischer, H. O. 1971. WOOD in a technological world. South. Lumberman 223(2776): 84-85. (FPL)

954. Fleischer, H. O. 1971. Wood--it's wonderful. Wood & Wood Prod. 76(11): 72C. (FPL)

955. Fleischer, H. O. 1971. The impact of utilization research on the complete use of the forest. Wood Sci. and Technol. 5(4): 247-254. (FPL)

956. Fleischer, H. O. 1971. More wood products into better utilization of our timber resources. Presented at Section Mtg. of the Society of American Foresters, Washington, D.C., 11 p. (FPL)

957. Forest Products Laboratory. 1971. Project STRETCH--research action to stretch timber resources in the environmental decade. USDA Forest Serv. unnumbered booklet, 12 p. (FPL)

958. Hall, J. Alfred. 1971. Bark - old and new. Proc. of Conf. on Converting Bark Into Opportunities, March 1971, 7 p. (PNW)

959. Heebink, B. G., and Ray Dominick. 1971. Forest residues: A future source of particleboard? Wood & Wood Prod. 76(11): 26-28. (FPL)

960. Plank, Marlin E. 1971. Red alder. USDA Forest Serv. American Woods FS-215, 7 p. (WO)

961. Taras, Michael A. 1971. Atlantic white cedar. USDA Forest Serv. American Woods FS-225, 7 p. (WO)

962. Zerbe, John I. 1971. Forest products for a better environment. Forest Prod. J. 21(6): 16-18. (WO)

Trees to enhance the environment

963. Cook, David I., and David F. Van Haverbeke. 1971. Trees and shrubs for noise abatement. Nebr. Agr. Exp. Sta. Res. Bul. 246, 77 p. (RM)[1]

964. Cunningham, Richard A. 1972. Development of Siberian and Dahurian larches after 10 years in North Dakota. USDA Forest Serv. Res. Note RM-209, 4 p. (RM)

965. Krochmal, Arnold, and Juanita Huguely. 1971. Seed descriptions of four common lobelias. Castanea 36: 257-259. (NE)

966. Read, Ralph A. 1971. Scots pine in eastern Nebraska: a provenance study. USDA Forest Serv. Res. Pap. RM-78, 13 p. (RM)

967. Walters, R. S. 1971. White pine provenances for Christmas trees in eastern Kentucky and Ohio. USDA Forest Serv. Res. Pap. NE-185, 16 p. (NE)

Natural regeneration

968. Bjorkbom, John C. 1971. Production and germination of paper birch seed and its dispersal into a forest opening. USDA Forest Serv. Res. Pap. NE-209, 14 p. (NE)

969. Bonner, F. T. 1971. Chemical content of southern hardwood fruits and seeds. USDA Forest Serv. Res. Note SO-136, 3 p. (SO)

970. Bonner, F. T., and G. L. Switzer. 1971. Upgrading yellow-poplar seeds. USDA Forest Serv. Res. Note SO-129, 4 p. (SO)

971. Croker, T. C., Jr. 1971. Binocular counts of longleaf pine strobili. USDA Forest Serv. Res. Note SO-127, 3 p. (SO)

972. DeBell, Dean S. 1971. Phytotoxic effects of cherrybark oak. Forest Sci. 17:180-185. (SE)

973. Grano, C. X. 1971. Conditioning loessial soils for natural loblolly and shortleaf pine seeding. USDA Forest Serv. Res. Note SO-116, 4 p. (SO)

974. Huntzinger, Harold J. 1971. Long-term storage of black cherry seed--is it effective? Tree Planters' Notes 22: 3-4. (NE)

975. Johnson, R. L. 1971. Timing and planning for hardwood regeneration in the Coastal Plains. Southeast Hardwoods Symp. Proc., USDA Forest Serv., Southeast Area, State and Private Forest, p. 44-49. (SO)

976. Phares, Robert E. 1971. Growth of red oak (Quercus rubra L.) seedlings in relation to light and nutrients. Ecol. 52: 669-672. (NC)

977. Rehfeldt, G. E., A. R. Stage, and R. T. Bingham. Strobili development in western white pine: periodicity, prediction, and association with weather. Forest Sci. 17: 454-461. (INT)

978. Sander, Ivan L. 1971. Height growth of new oak sprouts depends on size of advance reproduction. J. Forest. 69: 809-811. (NC)

979. Shearer, Raymond C. 1971. Silvicultural systems in western larch forests. J. Forest. 69: 732-735. (INT)

980. Sundahl, William E. 1971. Seedfall from young-growth ponderosa pine. J. Forest. 69: 790-792. (PSW)

[1] This publication begins the list for Timber Management Research.

981. Trimble, G. R., Jr. 1972. Reproduction 7 years after seed-tree harvest cutting in Appalachian hardwoods. USDA Forest Serv. Res. Pap. NE-223, 19 p. (NE)

982. Yocom, H. A. 1971. Releasing shortleaf pine increases cone and seed production. USDA Forest Serv. Res. Note SO-125, 2 p. (SO)

983. Zasada, John C. 1971. Natural regeneration of interior Alaska forests--seed, seedbed, and vegetative reproduction considerations. In Proc. Fire in the Northern Environment--A Symp. USDA, Forest Serv., PNW Forest and Range Exp. Sta., 231-246. (PNW)

984. Zasada, John C. 1971. Frost damage to white spruce cones in interior Alaska. USDA Forest Serv. Res. Note PNW-149, 7 p. (PNW)

Silvicultural methods

985. Alexander, Robert R. 1971. Initial partial cutting in old-growth spruce-fir. USDA Forest Serv. Res. Pap. RM-76, 8 p. (RM)

986. Alexander, Robert R. 1971. Initial partial cutting in old-growth spruce-fir: A field guide. USDA Forest Serv. Res. Pap. RM-76a, 6 p. (NC)

987. Clark, F. Bryan, and Richard F. Watt. 1971. Silvicultural methods for regenerating oaks. Oak Symp. Proc., Morgantown, W. Va., p. 37-43. (NC)

988. Farr, Wilbur A., and A. S. Harris. 1971. Effects of partial cutting of western hemlock and Sitka spruce in southeast Alaska. USDA Forest Serv. Res. Pap. PNW-124, 10 p. (PNW)

989. McDonald, Phillip M., and Raymond V. Whiteley. 1972. Logging a roadside stand to protect scenic values. J. Forest. 70:80-83. (PSW)

990. Sander, Ivan L., and F. Bryan Clark. 1971. Reproduction of upland hardwood forests in the Central States. USDA, Agr. Handb. 405, 25 p. (NC)

991. Schubert, Gilbert H. 1971. Growth response of even-aged ponderosa pines related to stand density levels. J. Forest. 69: 857-860. (RM)

992. Wellner, C. A. 1970. Regeneration problems of ponderosa pine in the Northern Rocky Mountains. Reprinted from Regeneration of Ponderosa Pine, Symp. p. 5-11. (INT)

Ecological relationships

993. Embry, Robert S. 1971. Soil water availability in an Arizona mixed conifer clearcutting. USDA Forest Serv. Res. Note RM-206, 4 p. (RM)

994. Franklin, Jerry F., William H. Moir, George W. Douglas, and Curt Wiberg. 1971. Invasion of subalpine meadows by trees in the Cascade Range, Washington and Oregon. Arctic and Alpine Res. 3(3): 215-224. (PNW)

995. Hatchell, G. E., and C. W. Ralston. 1971. Natural recovery of surface soils disturbed in logging. Tree Planters' Notes 22: 5-9. (SE)

996. Jones, John R. 1971. An experiment in modeling Rocky Mountain forest ecosystems. USDA Forest Serv. Res. Pap. RM-75, 19 p. (RM)

997. Minore, Don. 1972. A classification of forest environments in the South Umpqua Basin. USDA Forest Serv. Res. Pap. PNW-129, 28 p. (PNW)

998. Minore, Don. 1971. Occurrence and growth of four northwestern tree species over shallow water tables. USDA Forest Serv. Res. Note PNW-160, 9 p. (PNW)

999. Schubert, Gilbert H., and W. J. Rietveld. 1970. Bristlecone pine--Its phenology, cone maturity, and seed production in the San Francisco Peaks, Arizona. USDA Forest Serv. Res. Note RM-180, 7 p. (RM)

1000. Schubert, Gilbert H. 1971. The phenology of bristlecone pine on the San Francisco Peaks of Arizona. J. Arizona Acad. of Sci. 6: 245-248. (RM)

1001. Van Cleve, Keith, Leslie A. Viereck, and Robert L. Schlenter. 1971. Accumulation of nitrogen in alder (Alnus) ecosystems near Fairbanks, Alaska. Arctic and Alpine Res. 3: 101-114. (PNW)

Site evaluation and soil improvement

1002. Auchmoody, L. R. 1972. Epicormic branching: Seasonal change, influence of fertilization, and frequency of occurrence in uncut stands. USDA Forest Serv. Res. Pap. NE-228, 8 p. (NE)

1003. Auchmoody, L. R. 1972. Nutrient properties of five West Virginia forest soils. USDA Forest Serv. Res. Note NE-145, 4 p. (NE)

1004. Beck, Donald E. 1971. Height growth patterns and site index of white pine in the Southern Appalachians. Forest Sci. 17: 252-260. (SE)

1005. Beck, Donald E. 1971. Polymorphic site index curves for white pine in the Southern Appalachians. USDA Forest Serv. Res. Pap. SE-80, 8 p. (SE)

1006. Bennett, Frank A. 1971. Equating site indices of slash pine plantations and natural stands. USDA Forest Serv. Res. Note SE-167, 4 p. (SE)

1007. Broadfoot, W. M., B. G. Blackmon, and J. B. Baker. 1971. Soil management for hardwood production. Southeast. Hardwoods Symp. Proc.:17-29. Sept. 5-16, 1971, Dothan, Alabama. USDA Forest Serv., Southeast. Area, State and Priv. Forest.

1008. Carmean, W. H. 1971. Site index curves for black, white, scarlet, and chestnut oaks in the Central States. USDA Forest Serv. Res. Pap. NC-62, 8 p. (NC)

1009. Carmean, W. H., and A. Vasilevsky. 1971. Site-index comparisons for tree species in northern Minnesota. USDA Forest Serv. Res. Pap. NC-65, 8 p. (NC)

1010. Dickson, Richard E. 1971. The effects of soil moisture, texture, and nutrient levels on the growth of black walnut. USDA Forest Serv. Res. Pap. NC-66, 7 p. (NC)

1011. Graney, D. L., and D. R. Bower. 1971. Site index curves for red and white oaks in the Boston Mountains of Arkansas. USDA Forest Serv. Res. Note SO-121, 4 p. (SO)

1012. Graney, D. L., and E. R. Ferguson. 1971. Site-quality relationships for shortleaf pine in the Boston Mountains of Arkansas. Forest Sci. 17: 16-22. (SO)

1013. Hoyle, M. C. 1971. Effects of the chemical environment on yellow birch root development and top growth. Plant and Soil 35: 623-633. (NE)

1014. Jorgensen, J. R., and C. G. Wells. 1971. Apparent nitrogen fixation in soil influenced by prescribed burning. SSSA Proc. 35: 806-810. (SE)

1015. Loftus, N. S. 1971. Yellow-poplar root development on Hartsells subsoils. USDA Forest Serv. Res. Note SO-131, 5 p. (SO)

1016. Metz, Louis J. 1971. Vertical movement of Acarina under moisture gradients. Pedobiologia 11: 262-268. (SE)

1017. Metz, Louis J., and Maurice H. Farrier. 1971. Prescribed burning and soil mesofauna on the Santee Experimental Forest. In Prescribed Burning Symp. Proc. USDA Forest Serv., Southeast. Forest Exp. Sta., p. 100-106. (SE)

1018. Powers, Robert F. 1972. Site index curves for unmanaged stands of California black oak. USDA Forest Serv. Res. Note PSW-262, 5 p. (PSW)

1019. Ralston, C. W., and G. E. Hatchell. 1971. Effects of prescribed burning on physical properties of soil. In Prescribed Burning Symp. Proc. USDA Forest Serv., Southeast. Forest Exp. Sta., p. 68-84. (SE)

1020. Schultz, R. P. 1971. Stimulation of flower and seed production in a young slash pine orchard. USDA Forest Serv. Res. Pap. SE-91, 10 p. (SE)

1021. Wells, Carol G. 1971. Effects of prescribed burning on soil chemical properties and nutrient availability. In Prescribed Burning Symp. Proc. Southeast. Forest Exp. Sta., USDA Forest Service, p. 86-97. (SE)

Artificial regeneration

1022. Barnett, J. P. 1971. Flotation in ethanol reduces storability of southern pine seeds. Forest Sci. 17: 50-51. (SO)

1023. Blackmon, B. G. 1971. Large planting holes not needed for cottonwood cuttings and seedlings in Mississippi Delta, USDA Forest Serv. Res. Note SO-132, 2 p. (SO)

1024. Boyd, R. J. 1971. Effects of soil fumigation on production of conifer nursery stock at two northern Rocky Mountain nurseries. USDA Forest Serv. Res. Pap. INT-91, 19 p. (INT)

1025. Campbell, T. E. 1971. Pine seed and seedling depredations by short-tailed crickets. J. Econ. Entomol. 64: 1490-1493. (SO)

1026. Campbell, T. E. 1971. Prairie crayfish: a hazard in direct seeding. USDA, Forest Serv. Tree Plant. Notes 22: 20-24. (SO)

1027. Campbell, T. E., and W. F. Mann, Jr. 1971. Site preparation boosts growth of direct-seeded slash pine. USDA Forest Serv. Res. Note SO-115, 4 p. (SO)

1028. Derr, H. J., and W. F. Mann, Jr. 1971. Direct-seeding pines in the South. USDA, Agr. Handb. 391, 68 p. (SO)

1029. Frank, Robert M., and Eugene L. Putnam. 1972. Seedling survival in spruce-fir after mechanical tree harvesting in strips. USDA Forest Serv. Res. Pap. NE-224, 16 p. (NE)

1030. Geary, T. F., and J. A. Zambrana. 1971. Comparative adaptability of conifers in Puerto Rico. IUFRO, Sect. 22 Symp., Topic 2. 9 p. (ITF)

1031. Graber, Raymond E. 1971. Frost heaving seedling losses can be reduced. Tree Planters' Notes 22: 24-28. (NE)

1032. Hall, Dale O. 1971. Ponderosa pine planting techniques, survival, and height growth in the Idaho Batholith. USDA Forest Serv. Res. Pap. INT-104, 28 p. (INT)

1033. Johnson, Paul S. 1971. Growth and survival of interplanted hardwoods in southern Wisconsin oak clearcuttings. USDA Forest Serv. Res. Note NC-118, 4 p. (NC)

1034. Krajicek, J. E., and R. D. Williams. 1971. Continued weed control benefits young planted black walnut. USDA Forest Serv. Res. Note NC-122, 3 p. (NC)

1035. Krinard, R. M. 1971. 12X12 initial spacings best in cottonwood plantations. Tree Planters' Notes 22: 17-19. (SO)

1036. Lotan, James E., and Allen K. Dahlgreen. 1971. Hand preparation of seedbeds improves spot seeding of lodgepole pine in Wyoming. USDA Forest Serv. Res. Note INT-148, 7 p. (INT)

1037. Mann, W. F., Jr. 1971. How to direct-seed the southern pines. Forest Farmer 30: 116-119. (SO)

1038. McNab, W. Henry, and E. V. Brender. 1971. Systematically harvesting a Piedmont farm woodlot. Ga. Forest Res. Counc. Res. Pap. 69, 5 p. (SE)

1039. Randall, W. K., and A. J. E. Miller. 1971. Mist propagation recommended for expanding cottonwood clones rapidly. Tree Planters' Notes 22: 9-13. (SO)

1040. Russell, T. E. 1971. Seeding and planting upland oaks. USDA, Forest Serv., Northeast. Forest Exp. Sta., Oak Symp. Proc.:49-54. (SO)

1041. Russell, T. E. 1971. Planting and direct seeding hardwoods in the southern Appalachians. In South. Appalachian Hardwoods Symp. Proc. 1970: 60-65. USDA Forest Serv., Southeastern Area State and Private Forest. (SO)

1042. Schultz, R. P. 1972. Root development of intensively cultivated slash pine. Soil Sci. Soc. Amer. Proc. 36: 158-162. (SE)

1043. Strothmann, R. O. 1971. Germination and survival of Douglas-fir in Northern California--effects of time of seeding, soil type, and aspect. USDA Forest Serv. Res. Note PSW-245, 6 p. (PSW)

1044. Wendel, G. W. 1972. Results of a 20-year test of hybrid poplars in West Virginia. USDA Forest Serv. Res. Pap. NE-237, 5 p. (NE)

1045. Whitesell, Craig D., and Myron O. Isherwood, Jr. 1971. Adaptability of 14 tree species to two Hydrol Humic Latosol soils in Hawaii. USDA Forest Serv. Res. Note PSW-236, 5 p. (PSW)

Stand improvement

1046. Brady, H. A. 1971. Other brush-control sprays compared to 2, 4, 5-T ester. South. Weed Sci. Soc. Proc. 24: 251-254. (SO)

1047. Brady, H. A. 1971. Initial defoliation as predictor of topkill in brush-control spraying. South. Weed Sci. Soc. Proc. 24: 246-250. (SO)

1048. Grano, C. X. 1971. Growth of planted loblolly pine after row and selective thinning. USDA Forest Serv. Res. Note SO-123, 3 p. (SO)

1049. Gratkowski, H. 1971. Midsummer foliage sprays on salmonberry and thimbleberry. USDA Forest Serv. Res. Note PNW-171, 5 p. (PNW)

1050. Hall. O., and H. A. Brady. 1971. Mixing herbicides alters their behavior in woody plants. South. Weed Sci. Soc. Proc. 24: 255-262. (SO)

1051. Harris, A. S. 1971. Experience with Douglas-fir in southeast Alaska. Northwest Sci. 45: 87-93. (PNW)

1052. McKnight, J. S., and R. L. Johnson. 1971. Growing hardwoods in southern lowlands. Forest Farmer 30: 58-67. (SO)

1053. Peevy, F. A. 1971. Application date and dosage influence kill of hardwoods by soil application of bromacil, fenuron, and picloram. South. Weed Sci. Soc. Proc. 24: 271-273. (SO)

1054. Peevy, F. A. 1971. Wide-spaced injections of herbicidal mixtures for controlling weed trees. South. Weed Sci. Soc. Proc. 24: 263-267. (SO)

1055. Trimble, George R., Jr. 1971. Some hardwood culls do not need treatment--and these can be identified. Northern Logger and Timber Processor 20: 12, 32-33. (NE)

1056. Trimble, George R., Jr. 1971. Early crop-tree release in even-aged stands of Appalachian hardwoods. USDA Forest Serv. Res. Pap. NE-203, 13 p. (NE)

1057. Trimble, George R., Jr., and R. L. Rosier. 1971. Elimination of scattered residual saplings left after clearcut harvesting of Appalachian hardwoods. USDA Forest Serv. Res. Note NE-146, 4 p. (NE)

Animal damage

1058. Crouch, G. L. 1971. Susceptibility of ponderosa, Jeffrey, and lodgepole pines to pocket gophers. NW Sci. 45: 252-256. (PNW)

1059. Crouch, G. L., and M. A. Radwan. 1971. Evaluation of R-55 and mestranol to protect Douglas-fir seed from deer mice. USDA Forest Serv. Res. Note PNW-170, 6 p. (PNW)

1060. Mann, W. F., Jr., T. E. Campbell, and J. P. Barnett. 1971. Loss of endrin from repellent-coated pine seed. USDA Forest Serv. Res. Note SO-135, 2 p. (SO)

1061. Radwan, M. A., and W. D. Ellis. 1971. Factors affecting endrin content of endrin-coated Douglas-fir seed. NW Sci. 45: 188-192. (PNW)

1062. Schmidt, Wyman C., and Raymond C. Shearer. 1971. Ponderosa pine seed--for animals or trees? USDA Forest Serv. Res. Pap. INT-112, 14 p. (INT)

1063. Shearer, Raymond C., and Wyman C. Schmidt. 1970. Natural regeneration in ponderosa pine forests of western Montana. USDA Forest Serv. Res. Pap. INT-86, 19 p. (INT)

1064. Shearer, Raymond C., and Wyman C. Schmidt. 1971. Ponderosa pine cone and seed losses. J. Forest. 69: 370-372. (INT)

Growth requirements

1065. Boyer, W. D., R. M. Romancier, and C. W. Ralston. 1971. Root respiration rates of four tree species grown in the field. Forest Sci. 17: 492-493. (SO)

1066. Burton, J. D. 1971. Prolonged flooding inhibits growth of loblolly pine seedlings. USDA Forest Serv. Res. Note SO-124, 4 p. (SO)

1067. Carl, C. M., Jr., and Albert G. Snow, Jr. 1971. Maturation of sugar maple seeds. USDA Forest Serv. Res. Pap. NE-217, 9 p. (NE)

1068. Cochran, P. H. 1971. Pumice particle bridging and nutrient levels affect lodgepole and ponderosa pine seedling development. USDA Forest Serv. Res. Note PNW-150, 10 p. (PNW)

1069. De Lanuza, J. Marcos. 1970. The determination of levels of iron, zinc and copper sufficient for growth of Monterey pine (Pinus radiata) and the characterization of deficiency and toxicity symptoms for these three elements. Instituto Forestal De Investigaciones Y Experiencias, Madrid, Final Technical Report, 409 p. (E25-FS-25.) (WO)

1070. Dickmann, Donald I. 1971. Chlorophyll, ribulose-1, 5-diphosphate carboxylase, and Hill reaction activity in developing leaves of Populus deltoides. Plant Physiol. 48: 143-145.

1071. Gordon, John C. 1971. Changes in total nitrogen, soluble protein, and peroxidases in the expanding leaf zone of eastern cottonwood. Plant Physiol. 47: 595-599. (NC)

1072. Hacskaylo, Edward. 1971. Mycorrhizae: Proceedings of the First North American Conference on Mycorrhizae. USDA Forest Serv. Misc. Publ. 1189, 255 p. (WO)

1073. Kuhlman, E. G., and Carol G. Wells. 1971. Phytophthora root rot and fertilization damage in Christmas tree plantations. Amer. Christmas Tree J. 15: 17-20. (SE)

1074. Larson, Philip R., and J. G. Isebrands. 1971. The plastochron index as applied to developmental studies of cottonwood. Can. J. For. Res. 1: 1-11. (NC)

1075. Ledig, E. T., F. H. Bormann, and K. F. Wenger. 1970. The distribution of dry matter growth between shoot and roots in loblolly pine. Bot. Gaz. 131: 349-359. (SO)

1076. McKee, W. H., Jr., and R. A. Sommers. 1971. Slash pines respond equally to nitrogen applications in fall and spring. USDA Forest Serv. Res. Note SO-128, 4 p. (SO)

1077. Radwan, M. A., G. L. Crouch, and H. S. Ward. 1971. Nursery fertilization of Douglas-fir seedlings with different forms of nitrogen. USDA Forest Serv. Res. Pap. PNW-113, 8 p. (PNW)

1078. Wodzicki, T. J., and S. Zajaczkowski. 1970. Methodical problems in studies on seasonal production of cambial xylem derivatives. Acta Soc. Bot. Pol. Vol. XXXIX, No. 3, p. 509-520. (WO)

1079. Zelawski, W., J. Kucharska, and J. Kinelska. 1971. Relationship between dry matter production and carbon dioxide absorption in seedlings of Scots pine (Pinus silvestris L.) in their second vegetation season. Acta Soc. Bot. Pol. Vol. XL, No. 2, p. 243-256. (WO)

Growth and yield

1080. Bennett, Frank A. 1971. Modern thinning practice--technical and economic effects. In South. Pine Management--today and tomorrow. La. State Univ., Div. of Contin. Educ., 20th Ann. Forest Symp., p. 33-45. (SE)

1081. Bennett, Frank A. 1971. The role of thinning and some other problems in management of slash pine plantations. USDA Forest Serv. Res. Pap. SE-86, 14 p. (SE)

1082. Erdmann, G. G., and R. M. Peterson, Jr. 1972. Crown release increases diameter growth and bole sprouting of pole-size yellow birch. USDA Forest Serv. Res. Note NC-130, 4 p. (NC)

1083. Farr, Wilbur A., and Vernon J. LaBau. 1971. Volume tables and equations for old-growth western redcedar and Alaska cedar in southeast Alaska. USDA Forest Serv. Res. Note PNW-167, 18 p. (PNW)

1084. Filip, Stanley M. 1971. An example of product yields from an even-aged northern hardwood stand in New Hampshire. Northern Logger and Timber Processor 19: 22-23. (NE)

1085. Fujimori, Takao. 1972. Primary productivity of a young Tsuga heterophylla stand and some speculations about biomass of forest communities on the Oregon Coast. USDA Forest Serv. Res. Pap. PNW-123, 11 p. (PNW)

1086. Seidel, K. W. 1971. Growth of young even-aged western larch stands after thinning in eastern Oregon. USDA Forest Serv. Res. Note PNW-165, 12 p. (PNW)

1087. Wick, Herbert L., and George T. Hashimoto. 1971. Frond development and stem growth of treefern in Hawaii. USDA Forest Serv. Res. Note PSW-237, 4 p. (PSW)

1088. Williamson, Richard L., and Frank E. Price. 1971. Initial thinning effects in 70- to 150-year-old Douglas-fir--western Oregon and Washington. USDA Forest Serv. Res. Pap. PNW-117, 15 p. (PNW)

Forest measurements

1089. Bower, D. R. 1971. Accuracy of Zeiss telemeter teletop and Barr and Stroud dendrometers. USDA Forest Serv. Res. Note SO-134, 3 p. (SO)

1090. Cole, Dennis M. 1971. A cubic-foot stand volume equation for lodgepole pine in Montana and Idaho. USDA Forest Serv. Res. Note INT-150, 8 p. (INT)

1091. Curtis, Robert O. 1971. A tree area power function and related stand density measures for Douglas-fir. Forest Sci. 17: 146-159. (PNW)

1092. Grosenbaugh, L. R. 1971. STX 1-11-71 for dendrometry of multistage 3P samples. USDA Forest Serv. Publ. FS-277, 63 p. (SE)

1093. Harms, William R. 1971. Estimating leaf-area growth in pine. Ecol. 52: 931-934. (SE)

1094. Johnson, Floyd A., James B. Lowrie, and Martin Gohlke. 1971. 3P sample log scaling. USDA Forest Serv. Res. Note PNW-162, 15 p. (PNW)

1095. Perala, Donald A. 1971. Growth and yield of black spruce on organic soils in Minnesota. USDA Forest Serv. Res. Pap. NC-56, 16 p. (NC)

1096. Schlaegel, Bryce E. 1971. Growth and yield of quaking aspen in north-central Minnesota. USDA Forest Serv. Res. Pap. NC-58, 11 p. (NC)

1097. Stage, Albert R. 1971. Sampling with probability proportional to size from a sorted list. USDA Forest Serv. Res. Pap. INT-88, 16 p. (INT)

1098. Swindel, Benee F., and David R. Bower. 1972. Rounding errors in the independent variables in a general linear model. Technometrics 14: 215-218. (SE)

Management planning

1099. Johnston, William F. 1971. Management guide for the black spruce type in the Lake States. USDA Forest Serv. Res. Pap. NC-64, 12 p. (NC)

1100. Mann, W. F., Jr. 1971. Early yields of slash pine planted on a cutover site at various spacings. USDA Forest Serv. Res. Pap. SO-69, 16 p. (SO)

1101. Mann, W. F., Jr., and T. R. Dell. 1971. Yields of 17-year-old loblolly pine planted on a cutover site at various spacing. USDA Forest Serv. Res. Pap. SO-70, 9 p. (SO)

1102. Myers, Clifford A. 1971. Field and computer procedures for managed-stand yield tables. USDA Forest Serv. Res. Pap. RM-79, 24 p. (RM)

1103. Myers, Clifford A., Frank G. Hawksworth, and James L. Stewart. 1971. Simulating yields of managed dwarf mistletoe-infested lodgepole pine stands. USDA Forest Serv. Res. Pap. RM-72, 15 p. (RM)

1104. Roach, Benjamin A. 1971. Research needed for improved management of upland oaks. Oak Symp., summary paper, Aug. 16-20, 1971, 12 p. (NE)

Maple syrup production

1105. Blum, Barton M. 1971. Some correlations between sugar maple tree characteristics and sap and sugar yields. USDA Forest Serv. Res. Note NE-143, 4 p. (NE)

1106. Gabriel, W. J. 1972. Selection and propagation of superior sap-sugar producing trees. Proc. 8th Conf. Maple Prod., p. 3-9. (NE)

1107. Smith, H. Clay, and Carter B. Gibbs. 1971. How many trees? Natl. Maple Syrup Digest 10: 5-7. (NE)

Naval stores

1108. Franklin, E. C., and E. B. Snyder. 1971. Variation and inheritance of monoterpene composition in longleaf pine. For. Sci. 17: 178-179.

1109. Squillace, A. E. 1971. Inheritance of monoterpene composition in cortical oleoresin of slash pine. Forest Sci. 17: 381-387.

1110. Squillace, A. E., G. W. Hedrick, and A. J. Green. 1971. Variation and inheritance of levopimaric acid content and its relationship to oleoresin yield in slash pine. Silvae Genet. 20: 90-91.

1111. Zavarin, Eugene, William B. Critchfield, and Karel Snajberk. 1971. Composition of the cortical and phloem monoterpenes of Abies lasiocarpa. Phytochemistry 10: 3229-3237. (PSW)

Distribution and classification of forest trees

1112. Andresen, John W., and Raphael J. Steinhoff. 1971. The taxonomy of Pinus flexilis and P. strobiformis. Phytologia 22: 57-70. (INT)

1113. Critchfield, William B. 1971. Profiles of California vegetation. USDA Forest Serv. Res. Pap. PSW-76, 54 p. (PSW)

1114. Steinhoff, R. J., and J. W. Andresen. 1971. Geographic variation in Pinus flexilis and Pinus strobiformis and its bearing on their taxonomic status. Silvae Genet. 20: 159-167. (INT)

1115. Viereck, L. A., and E. L. Little, Jr. 1972. Alaska trees and shrubs. USDA, Agr. Handb. 410, 259 p.

Inherent variation

1116. Conkle, M. Thompson. 1971. Inheritance of alcohol dehydrogenase and leucine aminopeptidase isozymes in knobcone pine. Forest Sci. 17: 190-194. (PSW)

1117. Echols, R. M., and M. Thompson Conkle. 1971. The influence of plantation and seed-source elevation on wood specific gravity of 29-year-old ponderosa pine. Forest Sci. 17: 388-394. (PSW)

1118. Fober, Henryk, and Maciej Giertych. 1971. Variation among Norway spruce of Polish provenances in seedling growth and mineral requirements. Arboretum Kornickie 16: 107-120. (WO)

1119. Fober, Henryk, and Maciej Giertych. 1971. Variability of Picea abies (L.) Karst. seed size, weight and mineral content in Poland. Arboretum Kornickie 16: 121-130. (WO)

1120. Gansel, C. R., R. H. Brendemuehl, E. P. Jones, Jr., and J. W. McMinn. 1971. Seed source effects in 5- and 10-year-old test plantings of slash pine in Georgia and Florida. Forest Sci. 17: 23-30. (SE)

1121. Peters, W. J. 1971. Variation on oleoresin yielding potential of selected slash pines. Forest Sci. 17: 306-307. (SE)

1122. Schmitt, D. M., and E. B. Snyder. 1971. Nanism and fusiform-rust resistance in slash x shortleaf pine hybrids. Forest Sci. 17: 274-278. (SO)

1123. Schreiner, E. J. 1971. Genetics of eastern cottonwood. USDA Forest Serv. Res. Pap. WO-11, 19 p. (NE)

1124. Silen, Roy R. Inheritance of stockiness in ponderosa pine families. USDA Forest Serv. Res. Note PNW-166, 12 p. (PNW)

1125. Sorensen, Frank C. 1971. Estimate of self-fertility in coastal Douglas-fir from inbreeding studies. Silvae Genet. 20: 115-120. (PNW)

1126. Tonzig, S., and E. Marré. 1970. Comparative studies on the photosynthetic efficiences of poplar hybrids, with investigations of the limiting factors. Univ. of Milano, final technical report, 13 p. (E15-FS-8) (WO)

1127. Winstead, Joe E. 1972. Fiber tracheid length and wood specific gravity of seedlings as ecotypic characters in Liquidambar styraciflua L. Ecology 53(1): 165-172. (WO)

Insect-disease resistance

1128. Derr, H. J. 1971. Brown-spot resistance among progenies of longleaf plus trees. 11th South. Forest Tree Improv. Conf. Proc., p. 45-51. (SO)

1129. Dinus, R. J. 1971. Phenotypic selection for fusiform rust resistance. 11th South. Forest Tree Improv. Conf. Proc., p. 68-75. (SO)

1130. Dinus, R. J. 1971. Breeding pest-resistant forest trees: Developments and trends. 11th South. Forest Tree Improv. Conf. Proc., p. 10-24. (SO)

1131. Dinus, R. J., and R. C. Schmidtling. 1971. Fusiform rust in loblolly and slash pines after cultivation and fertilization. USDA Forest Serv. Res. Pap. SO-68, 10 p. (SO)

1132. Randall, W. K. 1971. Willow clones differ in susceptibility to cottonwood leaf beetle. 11th South. Forest Tree Improv. Conf. Proc., p. 108-111. (SO)

1133. Wells, O. O., and G. L. Switzer. 1971. Variation in rust resistance in Mississippi loblolly pine. 11th South. Forest Tree Improv. Conf. Proc., p. 25-30. (SO)

Tree breeding methodology

1134. Ledig, F. T., J. W. Beland, IV, and J. H. Fryer. 1971. Breeding techniques for white oak. 11th South. Forest Tree Improv. Conf. Proc., p. 275-283. (SO)

1135. Nanda, K. K., and M. K. Jain. 1971. Interaction effects of glucose and auxins in rooting etiolated stem segments of Salix tetrasperma. New Phytol. 70: 945-948. (WO)

1136. Nanda, K. K., M. K. Jain, and Shiva Malhotra. 1971. Effect of glucose and auxins in rooting etiolated stem segments of Populus nigra. Physiol. Plant. 24:387-391. (WO)

1137. Nanda, K. K., V. K. Anand, V. K. Kochhar, and M. K. Jain. 1971. Studies of the physiology of rooting of stem cuttings. Indian Agric. 15: 49-57. (WO)

1138. Snyder, E. B., and R. M. Allen. 1971. Competitive ability of slash pine analyzed by genotype x environment stability method. 11th South. Forest Tree Improv. Conf. Proc., p. 142-147. (SO)

INDEX

Abies 537 (111)
absorption, sound 6 (208, 209)
acacia, blackwood 475 (1045)
accident prevention 318 (552)
acid, levopimaric 536 (1110)
adhesives 587 (840)
aerial logging 356, 362 (765, 780)
  photography 50, 230-237, 427 (168, 169, 386, 742, 744-747, 749-751)
  seeding 4 (196)
  spraying 197, 198 (720-722)
Aero-Fire, Project 78 (347)
Aerobacter aerogenes 186 (696)
aerosols 196 (725)
aesthetics 27 (141)
Agathis pumila 227 (743)
air drying 562 (812)
  flotation 359 (784)
  pollution 295, 296, 431, 596-598 (398, 490, 493, 494, 890, 894, 902)
  pollution damage 297, 298 (491, 493)
  quality 74 (327-329, 337, 340, 344)
  seasoning 579 (859)
airflow 430 (399)
airlayering 472 (1042)
Alaska, climatic areas 434 (406)
  fire danger fluctuations 82 (357)
  interior forests 403 (983)
Alaska-cedar 511 (1083)
Alaska wildfire statistics 93 (362)
Alcaligenes faecalis 186 (696)
alder, 419 (1001)
  Nepal 475 (1045)
  red 245, 417 (415, 998)
aldrin 212, 214 (709, 714)
allowable cut 343, 349 (17, 18)
Alpine plants 58 (178)
anaerobic bacterium 305 (516, 517)
analysis, plant 50 (168, 169)
anemometers 109 (378)
animal browsing 275 (455)
  damage 488-493 (1058-1064)
  feed 597 (890)
  nutrition 8 (312)
animal-soil-plant relations 15, 53, 57, 59 (171, 177, 179, 316, 317)
annosus root rot 242-244, 254 (409, 413, 426, 427, 440)
ant, town 150, 170 (619, 683)
antagonism 246 (422)
antibiotics 321 (545)
apartment construction 622 (59)
Apechthis ontario 179 (701)
  velox occidentalis 177 (704)
aphid, balsam woolly 182, 185 (685, 688)
Appalachian hardwoods 401, 485-487 (981, 1055-1057)
applicators, retardant 86 (354)
appraisal, resource 338 (131)
aquatic habitat 383, 385 (290, 291)
area, forest 325-327, 349 (18, 87, 92-94, 99, 100, 102, 103)
Argyrotaenia citrana 199 (727)
Armillaria root rot 256, 257 (424, 433, 434, 437)
arsenic 5 (207)
artificial regeneration 455-475, 488, 491, 497, 531, 556, (1022-1045, 1058, 1061, 1068, 1104, 1132)
ash, green 118 (613)
  white 465 (1033)
ash bark beetle 118 (613)
aspect 372 (239)
aspen, 276 (451, 452)
  quaking 142, 403, 415, 524 (623, 624, 983, 996, 1096)
aspen lumber 582 (868)
  residues 597 (890)
Aspergillus 186 (696)
assistance programs 352 (26)
ASTM standards 308 (504)
attitudes 21, 23-25, 29-33 (133, 137-139, 143-147)
attractant, host 168 (657)
  sex 168 (657)
attractants 116, 157, 160, 225 (603, 664, 672, 736)

Bacillus thuringiensis 188 (687)
bacterial diseases 321 (545)
bacterium, anaerobic 305 (516, 517)
balloon logging 356, 362 (765, 780)
balsam woolly aphid 182, 185 (685, 688)
bark 597, 598, 600, 617, 618 (28, 31, 890, 896, 897, 902, 911, 913)
  anatomy 565, 584 (806, 839)
  beetles 112 (627)
  burning 588 (846)
  mulches 3 (195)
  separation 359, 565 (784, 806)
  structure 584 (839)
  utilization 565, 588 (806, 846)
barrel staves 139 (579)
basal areas 523 (1095)
baygon 209 (732)
beams, laminated 606 (938)
beetle,
  bark, ash 118 (613)
    elm 119, 175 (612, 690)
    oak 288 (481, 482)
    pine 111, 113-117 (573, 584, 603, 620, 630)
    smaller European elm 157, 158, 206, 207 (667, 672, 706, 707)
  Columbian timber 140, 141 (621, 622)
  fir engraver 225 (736)
  mountain pine 111, 113, 117, 181, 219, 221, (573, 616, 630, 702, 733, 735)
  southern pine 115, 116, 172, 180, 186, 223, (603, 620, 668, 696, 697, 738)
  western pine 171, 172, 205 (660, 668, 715)
beetles, bark 112 (627)
  Dendroctonus 220 (734)
  lyctus 165 (670)
  pine bark 230 (749)
behavior 29 (143)
bending jigs 589 (848)
benomyl 286 (477, 479, 480)
best opening face 573 (792, 957)
bibliography, annosus root rot 242 (413)
  seed and cone insects 135 (574)
  wood decay control 303 (497)
biological control 182, 183, 227, 243, 254 (426, 427, 440, 685, 700, 743)
  evaluations 117 (630)
biology 278 (466)
biomass 419 (1001)
birch, paper 388, 403, 512 (968, 983, 1084)
  river 494 (1065)
  yellow 275, 446, 510 (455, 1013, 1082)
birds, game 17 (319)
bispectral system 420-422 (387-389, 391, 394, 397)
blackwood acacia 475 (1045)
bleaching 599 (891, 898, 899)
blight, pole 319 (550)
  tip, Sirococcus 316 (562)
bluestem, little 76 (339)
board 602 (906)
borer, locust 143 (650)
borers, hardwood 139-142, 184 (579, 621-624, 703)
  shoot 124 (617)
Bracon politiventris 176 (695)
breeding, 558 (1134)
  tree 541 (1122)
bridge design 613 (941)
Bromus tectorum 53 (171)
brown spot 552 (1128)
brown spot needle blight 290 (485)
browse plant ecology 52 (172, 173)
  plants 152 (627)
  ranges 7 (310)
browsing, animal 275 (455)
brush control 477 (1047)
brushland conversion 2 (194)
budgeting, capital 339 (4)
budworm, jack pine 121, 162 (606, 658)
  spruce 161, 164, 176, 195, 196, 200, 218 (655, 676, 695, 719, 725, 728, 731)
  western spruce 166 (677)
burned area reforestation 403 (983)
burning, 368, 384 (237, 287)
  prescribed 450, 452, 454 (1017, 1019, 1021)
burns, prescribed 77 (343)
butterfly, pine 202 (717)
byproducts 329 (113, 115, 116)

cacodylic acid 288 (481, 482)
California five-spined engraver 205 (715)
California maps 539 (1113)
caliper, optical 337 (128)
campgrounds 31, 33, 35, 37, 43 (145, 147, 149, 151, 157)
canker, Ceratocystis 274, 276 (451, 452, 462)
Diplodia 274 (462)
Septoria 277 (446)
canker fungi 273 (454)
cankers 275 (455)
cankerworm, fall 228 (748)
capital budgeting 339 (4)
carbon-14 dating 20 (132)
carpenter worms 138 (634)
casebearer, larch 227 (743)
cedar, deodar 258 (408)
incense 120 (638)
cellulose 599, 604 (891, 898, 899, 907-909)
census 16 (320)
Ceratocystis canker 274, 276 (451, 452, 462)
characteristics, user 23 (137)
chemical control 306 (506, 507)
properties, seeds 389 (969)
safety 5 (207)
chemicals, 598, 600 (896, 897, 902, 911, 913)
forest 4 (196)
root 256 (424, 433, 434)
chemicals in the forest environment 489 (1059)
chemosterilants 161 (655)
chemosystemics 537 (1111)
cherry, black 394, 471 (974, 1040, 1041)
chip storage 310, 601 (502, 503, 886, 887, 903, 904)
chipping headrigs 590 (845)
chlordane 212, 214 (709, 714)
Christmas trees 63, 64, 261, 292, 502, 627 (49, 414, 486, 966, 967, 1073)
chromoproteins 164 (676)
citrus species 253 (421)
classification, 278 (466)
forest trees 538-540 (1112, 1113, 1115)
clearcutting 465, 487, 512 (1033, 1057, 1084)
climate 319 (550)
climatic areas, Alaska 434 (406)
climatological influences 98 (372)
cloud models 428 (400)
Coeloides pissodes 180 (697)
Coleotechnites 203 (718)
coloration, larvae 164 (676)
Columbian timber beetle 140, 141 (621, 622)
comandra rust 272 (460)
compaction, soil 414, 440 (995, 1007)
competition, 560 (1138)
regional 354, 355 (23, 25)
computer model, firefighting 90 (360)
program 520, 529, 530, 591 (836, 1092, 1102, 1103)
conductivity, hydraulic 387 (302)
cone and seed production 492 (1062
moth 169 (665)
production 391, 397, 402 (971, 977, 982)
conflagrations 84 (348)
conifer diseases 314 (520, 531)
conifers, mixed 408, 412 (989, 993)
needle structure 322 (554)
containers 605 (932)
contour trenching 369 (217)
conversion factors 564 (789)
corrugating medium 605 (932)
costs 346-348 (10, 13, 15)
cottonwood, 456, 467, 470, 499 (1023, 1035, 1039, 1070)
eastern 277, 500, 547 (446, 1071, 1123)
swamp 249 (410, 428, 429)
county statistics 328 (88)
crayfish, prairie 458 (1025, 1026)
creeping sage 72 (334)
crickets, short-tailed 458 (1025, 1026)
cross-grain planing 582 (868)
crossties 623 (50)
crown gall 321 (545)
release 510 (1082)
cull 485 (1055)
cultural practices 482, 561 (812, 1052)
treatments 485, 487, 568 (808, 1055, 1057)
cut, allowable 343, 349 (17, 18)
cutover forest range 54 (167, 174)
cutting, effects 364 (234)
partial 407 (988)
cuttings, forest 383 (291)
cypress 123 (590)
cytology 279 (469, 471, 474)

DDT 199, 202, 204 (716, 717, 727)
decay, 138, 299 (495, 634)
wood 301, 304-308, 310 (502-504, 506, 507, 509-511, 515-518)
wood, in ships 309 (505)
decay control 302 (500, 501, 512)
estimation 299 (495)
resistance 308 (504)
decision rules 424 (392, 396)
decking 610 (915)
declines 322 (554)
deer 10, 13, 14 (313, 314, 318)
defect indicators 574 (786)
defoliation, insect 256 (424, 433, 434)
defoliators 120-123, 556 (590, 602, 606, 638, 1132)
degrade, drying 562 (812)
lumber 141 (621)
demand 622, 623, 625-628 (41, 44-47, 49, 50, 54, 59)
Dendroctonus beetles 220 (734)
Dendrosoter protuberans 175 (690)
development, plant 51 (170)
diammonium phosphate 88 (358)
Dibrachys cavus 201 (726)
dichlorvos 205 (715)
dicrotophos 206, 215 (707, 723)
dieback 322 (554)
dieldrin 211, 212, 214 (708, 709, 714)
dimension cuttings 571 (809, 810)
grades 571 (809, 810)
parts 581 (829, 872)
dimethoate 194, 208 (712, 729)
Dioryctria abietella 169 (665)
Diplodia canker 274 (462)
shoot blight 293 (483)
direct seeding 458-460, 463, 468, 471, 473, 490, 491, (1025-1028, 1036, 1037, 1040, 1041, 1043, 1060, 1061)
discharge, peak 369 (217)
disease, Dutch elm 286 (477, 479, 480)
littleleaf 262 (431)
disease control 286, 288, 289, 294, 314, 321 (477-482, 488, 520, 531, 545)
diseases, bacterial 321 (545)
conifer 314 (520, 531)
hardwood 314 (520, 531)
diseases of forest trees 315 (543)
of shade trees 315 (543)
dispersal 162 (658)
distribution, forest trees 539, 540 (1112, 1113, 1115)
disulfoton 210 (730)
dormancy, breaking 72 (334)
Dothistroma needle blight 292 (486)
Douglas-fir 193, 218, 240, 245, 247, 254, 255, 298, 317, 457, 473, 481, 489, 491, 506, 516, 519, 544 (415, 435, 436, 438, 440, 493, 564, 689, 719, 756, 1024, 1043, 1051, 1059, 1061, 1077, 1088, 1091, 1125)
drought resistance 322 (554)
dry matter production 504 (1075)
drying, wood 585 (842, 843)
drying conditions 98 (372)
costs 580 (875)
degrade 562, 580 (812, 875)
procedures 579 (859)
durability of wood in ships 309 (505)
Dursban 205 (715)
Dutch elm disease 119, 286 (477, 479, 480, 612)
dwarf mistletoe 282-284, 530 (464, 470, 472, 473, 1103)
mistletoe control 280, 282, 284 (464, 470, 473)
mistletoe glossary 281 (465)
mistletoes 278, 279 (466, 469, 471, 474)
dwarfing 541 (1122)

eastern gall rust 268, 269 (445, 459)
ecological management 241 (757)
relationships 412-419 (993-1001)
ecology, 19, 20, 22 (132, 134-136)
browse plant 52 (172, 173)
plant 50, 51, 53, 58 (168-171, 178)

econometrics 148 (600)
economic development 616 (36)
ecosystem development 419 (1001)
ecosystems 94 (382)
ectomycorrhizae 252, 255 (420, 438)
effects of cutting 364 (234)
egg galleries 113 (573)
electro-physiology 168 (657)
elevational profiles 539 (1113)
elk 9, 14, 54 (167, 174, 315, 318)
elm, 286 (477, 479, 480)
American 320 (572)
elm bark beetle 119, 175 (612, 690)
phloem necrosis 320 (572)
spanworm 163 (663)
elms 119, 157 (612, 672)
employment, 628 (44-47)
rural 616 (36)
endomycorrhizae 253 (421)
endrin 4, 489, 491 (196, 1059, 1061)
energy budget 367 (220)
contents 99 (381)
engraver, California five-spined 205 (715)
environment, Alaska, fire relationship 92 (361, 384)
forest 357 (770)
forest, chemicals 489 (1059)
environment improvement 66 (963)
environmental classes 416 (997)
enhancement 6 (208, 209)
influences 504 (1075)
stress 256 (424, 433, 434)
enzyme inhibitors 285 (467, 468)
enzymes 285 (467, 468)
epicormic sprouting 436, 510 (1002, 1082)
equilibrium moisture content 97, 576, 593 (365, 366, 854, 862)
erosion 2, 366, 370, 373, 378, 380, 381 (194, 215, 221, 231, 232, 270, 278, 281)
control 1, 379 (184, 282)
ERTS 237 (751)
ether extractive 99 (381)
European pine sawfly 187, 229 (691, 753)
pine shoot moth 124, 159, 160 (617, 661, 664)
evaporation 386 (307)
even-aged management 486, 512, 531 (1056, 1084, 1104)
export markets 624, 628 (44-47, 51)
exterior finishing 578 (871)
woodwork 304 (511, 518)
extractive removal 592 (818)
extractives 598, 600 (896, 897, 902, 911, 913)
exudation pressure, oleoresin 224 (737)

fall cankerworm 228 (748)
fasteners 607, 608 (922, 945)
feed, animal 597 (890)
feeder root pathogens 260 (412)
feeding stimulant 155 (682)
Ferbam 216, 324 (540, 711)
fertilization 59, 60, 396, 436, 443, 453, 505, 506, 561, (179, 180, 812, 976, 1002, 1010, 1020, 1076, 1077)
fertilizers 502 (1073)
fescue 379 (282)
fiber production 568 (808)
products 612 (937)
fiberboard 602 (906)
fiberboards 605 (932)
fibers 603, 604 (877, 878, 907-909)
financial analysis 343 (17)
evaluation 339-342 (2-4, 6)
maturity 345 (9)
finger joints 606 (938)
finish failures 578 (871)
finishes, housing 609 (924)
finishing, exterior 578 (871)
fir, 225 (736)
Fraser 261, 502 (414, 1073)
subalpine 405 (985, 986)
white 566 (803)
fir engraver beetle 225 (736)
fire, 381 (281)
natural agent 96 (385)
prescribed 75 (336)
fire control 71 (333)
danger fluctuations, Alaska 82 (357)
danger rating 79 (349, 350)
detection 420 (387, 397)
hazard 70 (321-323)
laws 627 (49)
pattern data 83 (359)
prevention 68 (326)
relationship, Alaska environment 92 (361, 384)
retardancy 577 (838)
role in management 94 (382)
simulation model 425 (393)
spotters 423 (389, 390)
study, wilderness 91 (345)
treatment, Montana forests 95 (364)
whirl winds 106 (373)
firefighting computer model 90 (360)
fires, forest 67 (325)
prescription 74 (327-329, 337, 340, 344)
fish habitat 382 (286)
fishing 45 (160)
flight behavior 111 (616)
flood reduction 376 (265)
flooding 495 (1066)
flora 19 (135, 136)
flotation, air 395 (784)
foliage 598 (902)
food plants, wildlife 8, 9, 13, 15, 17, 52 (172, 173, 312, 313, 315-317, 319)
forage plants, 51, 58, 59 (170, 178, 179)
production 54 (167, 174)
forest area 325-327, 349 (18, 87, 92-94, 99, 100, 102, 103)
chemicals 4 (196)
cuttings 383 (291)
environment 357 (770)
fires 67 (325)
floor 449 (1016)
fungi 311 (521, 522, 524-529, 532-537)
industries 353-355, 618-620 (23-25, 29, 31, 32)
management 15, 469, 527 (316, 317, 1038, 1099)
measurements 517-526 (1089-1098)
multiple use 55, 56, 60 (175, 176, 180)
pest management 238-241 (754-757)
practices, costs 347 (15)
range, cutover 54 (167, 174)
ranges 55, 56, 60 (175, 176, 180)
recreation 18, 30-38, 43, 47 (144-152, 157, 158, 164)
recreational use 39-41, 45, 46, 49 (153-155, 159, 160, 162, 163, 166)
regulation 342, 343, 349 (3, 17, 18)
roads 357 (770)
safety 318 (552)
soils 371 (210)
succession 419 (1001)
survey 326, 327, 338 (87, 92-94, 102, 103, 131)
tree diseases 315 (543)
forest-wildlife relations 7, 11, 13-15, 17 (310, 311, 313, 316-319)
forests, hardwood 367 (220)
spruce-fir 461 (1029)
fourwing saltbush 73 (335)
fronts 433 (407)
frost damage 404, 463 (984, 1031)
fuel appraisal 100 (368)
breaks 71, 73 (333, 335)
management 96 (385)
moisture 80, 81 (351, 352)
reduction 96 (385)
volumes 100 (368)
fuels, slash 105 (369)
fungal growth, effect of temperature 273 (454)
pathogens 313 (519, 530)
fungi, canker 273 (454)
forest 311 (521, 522, 524-529, 532-537)
hardwood seed 312 (523)
insect transmission 276 (451, 452)
wood-rotting 300, 301 (496, 509, 510)
fungicide 324 (540)
fungicides 294, 316 (488, 562)
furadan 209 (732)
furniture dimension 581 (829, 872)
industry 626, 629 (41, 48)
Fusarium nivale 185 (688)
fusiform rust 268-271, 541, 553-555, 557 (444, 445, 459, 461, 1122, 1129-1131, 1133)
fertilization 568 (808)
fuzzy grain 582 (863)

gall, crown 321 (545)
game, small 16 (320)
game birds 17 (319)
Ganoderma root rot 313 (519, 530)

gene-environment interaction 545, 548, 560 (1126-1128)
genetic resistance 263, 265, 270, 295 (442, 461, 463, 490)
variation 63, 64, 532, 543, 546, 554, 557 (966, 967, 1106, 1116, 1118, 1119, 1130, 1133)
genetics 8, 536, 548-550 (312, 1110, 1121, 1124, 1126)
genotype, host 252 (420)
genotype-environment interaction 546 (1118, 1119)
geographic selections 262 (431)
Georgia wildfires 83 (359)
germ-free culture 323 (538, 547, 549, 565-571)
germination, 496 (1067)
seed 52, 61 (172, 173, 181)
gibberellic acid 72 (334)
Glena bisulca 123 (590)
glossary, dwarf mistletoe 281 (465)
Gnothothrips fuscus 131, 216 (586, 711)
gophers, pocket 488 (1058)
grade recovery 566 (803)
grain, fuzzy 582 (868)
grasslands, mountain 54 (167, 174)
grazing 14, 53, 55-57, 380 (171, 175-177, 278, 318)
ground water 351 (16)
ground-water measurement 387 (302)
ground-water pollution 351 (16)
group selection 531 (1104)
growth, 501 (1072)
timber 326 (87, 92, 94, 102, 103)
growth and yield 509-516, 523, 524 (1080-1088, 1095, 1096)
requirements 494-508 (1065-1079)
grubs, white 144 (594)
guardrails, wood 595 (831)
gum naval stores 358 (767)
gypsy moth 187-191, 238, 239 (686, 687, 691, 693, 699, 754, 755)

habitat, aquatic 383, 385 (290, 291)
fish 382 (286)
habitats, 11 (311)
remote-sensing 50 (168, 169)
hardboard 602, 622 (59, 906)
hardwood borers 139-142, 184 (579, 621-624, 703)
control 476 (1046)
diseases 314 (520, 531)
forests 367 (220)
logs 629 (48)
lumber 620 (32)
planting 466 (1034)
plywood 625 (54)
seed 312 (523)
seed fungi 312 (523)
veneer 335 (117, 122, 126)
hardwoods, 477, 559 (1047, 1135-1137)
Appalachian 401, 485-487 (981, 1055-1057)
central 406 (987)
low-grade 620, 621 (32, 35)
mixed 392 (972)
northern 442, 512 (1009, 1084)
planting 471 (1040, 1041)
southern 395, 440, 482 (975, 1007, 1052)
upland 409 (990)
harvesting, 482 (1052)
log 360 (776)
mechanical 478 (1048)
harvesting systems 358 (767)
hazard, fire 70 (321-323)
hazard evaluation 318 (552)
hazards, health 5 (207)
health hazards 5 (207)
heat resistance 322 (554)
helicopter spraying 207 (706)
hemlock, western 122, 240, 247, 407, 417, 513 (435, 436, 602, 756, 988, 998, 1085)
heptachlor 212-214, 216 (709-711, 714)
herbaceous vegetation 81 (352)
herbicide 477, 483 (1047, 1053)
herbicide treatments 70 (321-323)
herbicides 197, 288, 476, 479, 480, 484 (481, 482, 720, 721, 1046, 1049, 1050, 1054)
hickory, pignut 163 (663)
mockernut 484 (1054)
highway posts 595 (831)
holography, laser 196 (725)
honeydew, insect 128 (580)
hormone, juvenile 166 (677)
host attractant 168 (657)
genotype 252 (420)
host-parasite relations 266 (447-450, 458)
host resistance 222, 226, 245 (415, 740, 741)
selection 225 (736)
housing 610, 622 (59, 915)
hybrid, slash x shortleaf 541 (1122)
hybrid poplar 474 (1044)
hydraulic conductivity 387 (302)
hydrogen peroxide 301 (509, 510)
hydrographs 373 (215)
hydrophobic soils 370 (221, 232)

Ichneumonidae 178 (705)
identification, tree 540 (1115)
identification key, insects 151 (637)
identification keys 114 (584)
inbreeding 544 (1125)
incense cedar 120 (638)
income taxes 348 (13)
indicator plants 416 (997)
industry, forest 353-355 (23-25)
infiltration 370, 371 (210, 221, 232)
information initiator 68 (326)
infrared 232-236, 421, 422, 424 (388, 389, 391, 392, 394, 396, 742, 744-747)
scanner 423 (389, 390)
system 426 (395)
inherent variation 541-544, 546-551 (1116-1126)
inhibitors, plant growth 3 (195)
initiator, information 68 (326)
insect control 132 (585)
defoliation 256 (424, 433, 434)
diet 122 (602)
insect-disease resistance 552-557 (1128-1133)
insect honeydew 128 (580)
identification 151 (637)
impacts 120, 123, 126, 128, 131, 134, 139, 141, 142, 144, 147, 148 (579, 580, 586, 590, 594, 600, 608, 621, 623, 624, 638, 649, 652, 654)
pathogen 185, 186, 188, 191 (687, 688, 693, 696)
pathogens 189, 190, 192, 193 (686, 689, 694, 699)
pollination 279 (469, 471, 474)
population studies 112 (627)
rearing 154, 156, 158, 159, 163, 165, 183 (661, 663, 667, 669, 670, 681, 700)
resistance 136, 556 (577, 1132)
sampling 228, 229, (748, 753)
survey methods 230, 231 (749, 750)
transmission of fungi 276 (451, 452)
insecticides, 194, 195, 197, 202, 204, 205, 207, 211, 213-215 (706, 708, 710, 712, 714-717, 720, 721, 723, 731)
systemic 209, 210 (730, 732)
insects, browse plant damage 152 (627)
seed and cone 129, 131, 132, 134, 135, 215 (574, 585, 586, 615, 627, 652, 654, 723)
seed orchard 169 (665)
instrumentation 337 (128)
integrated control 146, 195, 238, 239 (641, 731, 754, 755)
interest tables 341 (6)
interpretation 48 (165)
inventory 325 (99, 100)
invertebrates 385 (290)
investment guide 344, 346 (8, 10)
investments 339, 340 (2, 4)
Ips calligraphus 153 (651)
cribricollis 153 (651)
grandicollis 173 (684)
pini 112 (627)
irrigation 453 (1020)
isothermal pyrolysis 102 (367)
isozyme, pine 543 (1116)
Itoplectis behrensii 201 (726)
quadricingulatus 179 (701)

jack-pine budworm 121, 162 (606, 658)
Java podocarpus 475 (1045)
juvenile hormone 166 (677)

keys 178 (705)
kiln drying 585 (842, 843)
koa 475, 574 (786, 1045)

labor 353 (24)
Lake States, operational burns 77 (343)
lakes 44 (161)
laminated beams 606 (938)
  timbers 593 (854)
  wood 613 (941)
lance nematode 248 (430)
land survey methods 232-237 (742, 744-747, 751)
landscape management 27, 28, 42, 48 (141, 142, 156, 165)
landscapes 25, 26, 42, 48 (139, 140, 156, 165)
larch, Siberian 65 (964)
  western 399, 514 (979, 1086)
larch casebearer 227 (743)
laser cutting 586 (852)
  holography 196 (725)
Laspeyresia ingens 133 (591)
  toreuta 133 (591)
leaf development 500 (1071)
  surface area 521 (1093)
leafhopper oviposition wounds 275 (455)
levopimaric acid 536 (1110)
light 396 (976)
lightning effects 429 (405)
  storms 428 (400)
lignin 103 (379)
lindane 205 (715)
linear programming 342, 343 (3, 17)
  regressions 149 (595)
lipids 155, 165 (670, 682)
Liquidambar 545 (1127)
literature, annosus root rot 242 (413)
litter sampling 110 (383)
littleleaf disease 262 (431)
load cells 108 (376)
lobelia 62 (965)
lobeline 62 (965)
locust, black 143 (650)
locust borer 143 (650)
log defects 574 (786)
  exports 624 (51)
  grades 570, 574 (786, 812)
  harvesting 360 (776)
  scaling 522 (1094)
  storage 302 (500, 501, 512)
logging, 368, 381, 382, 384 (237, 281, 286, 287)
  aerial 356, 362 (765, 780)
  balloon 356, 362 (765, 780)
  skyline 361 (766)
logging effects 408 (989)
  equipment 360, 362 (765, 776)
  residue 621 (35)
  residue volumes 101 (371)
  roads 373, 378 (215, 270)
  systems 361 (766)
looper, western hemlock 177 (704)
Lophodermium needle cast 294 (488)
lumber 614, 622, 623, 626, 628 (41, 44-47, 50, 59, 953, 955, 956)
  degrade 140, 141 (621, 622)
  drying 566, 579 (803, 859)
  grades 563, 566, 571 (794, 803, 809, 810)
  manufacture 594 (857)
  production 353, 355 (23, 24)
  standards 614 (953, 955, 956)
  yields 573 (792, 957)
lunar material 323 (538, 547, 549, 565-571)
lyctus beetles 165 (670)

machining defects 583 (870)
  processes 586 (852)
macrospores 371 (210)
malathion 199, 203, 205, 216 (711, 715, 718, 727)
management, 22 (134)
  ecological 241 (757)
  even-aged 486, 512, 531 (1056, 1084, 1104)
  forest 15, 469, 527 (316, 317, 1038, 1099)
  forest pest 238-241 (754-757)
  landscape 27, 28, 42, 48 (141, 142, 156, 165)
  multiple-use 376 (265)
  nursery 457 (1024)
  range 7-9, 14, 52, 53, 55-57, 59-61 (171-173, 175-177, 179-181, 310, 312, 315, 318)
  recreation site 413 (994)
  resource 94 (382)
  snowpack 374 (267)
  timber 527, 529, 530 (1099, 1102, 1103)
  wildlife 7-16 (309-318, 320)
  woodlot 469 (1038)
management planning 512, 527-531 (1084, 1099-1104)
maneb 294 (488)
maple, 286 (477, 479, 480)
  red 249, 296, 306, 480 (410, 428, 429, 494, 506, 507, 1050)
  sugar 256, 496, 532-534 (424, 433, 434, 1067, 1105-1107)
maple syrup production 532-534 (1105-1107)
marketing 141 (621)
mass loss rates, fuel 108 (376)
mathematical models 148, 149, 415 (595, 600, 996)
  predictions 105 (369)
meadows, subalpine 413 (994)
measurement, ground-water 387 (302)
measurements, 337, 520 (128, 1092)
  forest 517-519, 521-526 (1089-1091, 1093-1098)
mechanical harvesting 478 (1048)
  properties 603 (877, 878)
  tree harvesting 461 (1029)
Medetera aldrichii 181 (702)
medicinal plants 62 (965)
mesofauna 450 (1017)
metabolism, protein 500 (1071)
methoxychlor 207 (706)
microbial control 191-193 (689, 693, 694)
microbiology, soil 4 (196)
microclimate 124, 137, 372 (239, 617, 632)
microfauna 449 (1016)
micrometeorology 111 (616)
microorganisms, 116 (603)
  succession 307 (515)
mineral nutrition 454, 498 (1021, 1069)
miners, needle 203 (718)
mistblower spraying 207 (706)
mistletoe, 285 (467, 468)
  dwarf 278-280, 282-284, 530 (464, 466, 469-474, 1103)
  dwarf, glossary 281 (465)
mites 114, 115 (584, 620)
model, fire after ignition 425 (393)
  probability 435 (402)
models, cloud 428 (400)
  mathematical 148, 149, 415 (595, 600, 996)
  predictive 40, 41, 43-46, 49 (154, 155, 157, 159-163, 166)
moisture 99, 416 (381, 997)
moisture content, equilibrium 97, 576 (365, 366, 862)
  stress 319 (550)
Monitor 210 (730)
monoterpene 535 (1108, 1109)
monoterpenes 226 (740)
moth, cone 169 (665)
  European pine shoot 124, 159, 160 (617, 661, 664)
  gypsy 187-191, 238, 239 (686, 687, 691, 693, 699, 754, 755)
  pandora 204 (716)
  tip, Nantucket pine 134, 153 (651, 652, 654)
  tip, western pine 208 (729)
  tussock 193 (689)
  wax 167 (656)
mountain grasslands 54 (167, 174)
  pine beetle 111, 113, 117, 181, 219, 221 (573, 616, 630, 702, 733, 735)
mulberry, white 313 (519, 530)
mulch 617 (28)
mulches, 61 (181)
  bark 3 (195)
multiple use 343, 349-351, 375, 405 (16-19, 253, 985, 986)
multiple use, forest 55, 56, 60 (175, 176, 180)
multiple-use management 376 (265)
municipal watersheds 375 (253)
mycangium 172 (668)
mycoplasma 320 (572)
mycorrhizae, 250, 251, 501 (416, 423, 425, 432, 439, 1072)
  tuberculate 254 (440)
myrcene 171 (660)

nails 608 (945)
nanism 541 (1122)
Nantucket pine tip moth 134, 153 (651, 652, 654)

natural beauty 27 (141)
regeneration 388-404, 406, 409, 493 (968-984, 987, 990, 1063, 1064)
naval stores 535-537, 598, 600 (896, 897, 902, 911, 913, 1108-1111)
naval stores, gum 358 (767)
needle blight 291 (484)
needle blight, brown spot 290 (485)
needle blight, Dothistroma 292 (486)
needle cast, Lophodermium 294 (488)
needle miners 203 (718)
needles 598 (902)
nematode, 118 (613)
lance 248 (430)
nematodes 249, 250 (410, 425, 428, 429)
neurological studies 167 (656)
nitrogen 419, 505, 506 (1001, 1076, 1077)
fixation 447 (1014)
noise abatement 6, 66 (208, 209, 963)
northern hardwoods 442, 512 (1009, 1084)
softwoods 442 (1009)
nursery fertilization 506 (1077)
management 457 (1024)
plantings 277 (446)
practice 470 (1039)
nutrient release 384 (287)
nutrients, soil 437, 440, 446 (1003, 1007, 1013)
nutrition, 501 (1072)
animal 8 (312)

oak, 286, 465, 580 (477, 479, 480, 875, 1033)
black 441, 444 (1008, 1011)
blackjack 483, 484 (1053, 1054)
California black 451 (1018)
cherrybark 392 (972)
chestnut 441 (1008)
northern red 444 (1011)
post 483 (1053)
red 163, 307, 396, 436 (515, 663, 976, 1002)
scarlet 441 (1008)
water 480 (1050)
white 307, 441, 444, 558 (515, 1008, 1011, 1134)
oak bark beetle 288 (481, 482)
oak-hickory type 345 (9)
oak lumber 594 (857)
oak-mountain mahogany 75 (336)
oak-pine 344 (8)
oak utilization 612 (937)
oak wilt 286-289 (475-482)
oaks, 398, 406, 437, 531 (978, 987, 1003, 1104)
upland 441, 471 (1008, 1040, 1041)
Oberea schaumii 142 (623, 624)
ohia 574 (786)
oleoresin 535, 549 (1108, 1109, 1121)
exudation pressure 224 (737)
Omemeea maxbassiensis 118 (613)
operations research 629 (48)
opinion leader 68 (326)
orange tortrix 199 (727)
ownerships, individual 352 (26)
oxygen-wood pulping reactions 599 (891, 898, 899)
ozone 297 (491)

packaging 605, 607 (922, 932)
painting 578 (871)
pales weevil 145, 146, 154-156, 210 (636, 641, 669, 681, 682, 730)
pallets 607, 620 (32, 922)
pan evaporation 386 (307)
pandora moth 204 (716)
panels, wood base 612 (937)
paper 596, 603, 604 (877, 878, 894, 907-909)
production 353 (24)
pulp 596 (894)
parallax readings 427 (386)
parasites 127, 175-181, 183 (588, 690, 695, 697, 700-702, 704, 705)
particleboard 622 (59)
pathogens, feeder root 260 (412)
fungal 313 (519, 530)
insect 185, 186, 188-193 (686-689, 693, 694, 696, 699)
root 250 (425)
pathology, recreation site 318 (552)
peak discharge 369 (217)
flows 365 (212)
pecan crops 130 (589)
weevil 130 (589)
Penicillium 186 (696)
Peniophora gigantea 243 (426, 427)
Peniophora root and butt rot 258 (408)
percolation 371 (210)
pesticide degradation 213 (710)
pesticides 4, 198 (196, 722)
phenology 418 (999, 1000)
pheromone 157, 171 (660, 672)
pheromones 160, 168-170 (657, 664, 665, 683)
phloem necrosis, elm 320 (572)
thickness 113 (573)
Pholeomyia comans 150 (619)
phorate 208, 209 (729, 732)
photography, aerial 50, 230-237, 427 (168, 169, 386, 742, 744-747, 749-751)
photosynthesis 499 (1070)
phreatophytes 363 (226)
Phryganidia californica 201 (726)
Phyllophaga 144 (594)
physiology, plant 500, 503 (1071, 1074)
tree 224 (737)
Phytophthora root rot 254, 260-262 (412, 414, 431, 440)
phytotoxins 392 (972)
Picea mariana 527 (1099)
pine, 598 (902)
Austrian 292, 293 (483, 486)
blue 282 (464)
bristlecone 418 (999, 1000)
Caribbean 153 (651)
coulter 298 (493)
eastern white 570 (812)
Jeffery 283, 298, 316, 488 (472, 493, 562, 1058)
loblolly 133, 134, 154, 155, 173, 223, 224, 259, 270, 272, 291, 393, 469, 476, 478, 480, 490, 494, 495, 504, 517, 521, 528, 553, 555, 557 (411, 460, 461, 484, 591, 652, 654, 669, 682, 684, 737, 738, 973, 1038, 1046, 1048, 1050, 1060, 1065, 1066, 1075, 1089, 1093, 1100, 1101, 1129, 1131, 1133)
lodgepole 219, 280, 468, 488, 497, 518, 530 (470, 733, 1036, 1058, 1068, 1090, 1103)
longleaf 391, 535, 552 (971, 1108, 1109, 1128)
Monterey 298, 498 (493, 1069)
ponderosa 112, 120, 171, 208, 220, 221, 257, 284, 293, 297, 298, 400, 410, 411, 451, 457, 464, 488, 492, 493, 497, 529, 542, 550, 592 (437, 473, 483, 491, 493, 627, 638, 660, 729, 734, 735, 818, 980, 991, 992, 1018, 1024, 1032, 1058, 1062-1064, 1068, 1102, 1117, 1124)
ponderosa, Black Hills 567 (816)
red 124-126, 129, 147, 229 (607, 608, 615, 617, 649, 753)
sand 248 (430)
Scotch (Scots) 64, 222, 229, 293, 294, 507, 508 (483, 488, 741, 753, 966, 1078, 1079)
shortleaf 133, 134, 244, 262, 272, 393, 402, 445 (409, 431, 460, 591, 652, 654, 973, 982, 1012)
slash 131, 132, 252, 291, 324, 439, 453, 455, 459, 472, 490, 505, 509, 528, 535, 549, 551, 553, 555, 560 (420, 484, 540, 585, 586, 1006, 1020, 1022, 1027, 1042, 1060, 1076, 1080, 1081, 1100, 1101, 1108, 1109, 1120, 1121, 1129, 1131, 1138)
southern 302, 344, 460, 554, 569, 590 (8, 500, 501, 512, 811, 845, 1028, 1037, 1130)
southern, properties 611 (917)
spruce 455 (1022)
Virginia 133 (591)
western white 264-267, 319, 397, 457 (447-450, 453, 456, 458, 463, 550, 977, 1024)
white 438, 463, 502 (1004, 1005, 1031, 1073)
whitebark 219 (733)
pine bark 584, 588, 600 (839, 846, 896, 897, 911, 913)
pine bark beetles 111, 113-117, 230 (573, 584, 603, 616, 620, 630, 749)
butterfly 202 (717)
needle sheathminer 120 (638)
planting 462 (1030)
root-collar weevil 222 (741)

pine - - continued
taxonomy 538 (1112)
wood, bending 589 (848)
Pinus caribaea 462 (1030)
flexilis 538 (1112)
strobiformis 538 (1112)
strobus 63 (967)
Pissodes 145 (636)
pitch-eating weevil 145 (636)
Pityophthorus bisculcatus 174 (698)
planing, cross-grain 582 (868)
wood 583 (870)
planning, 26, 28 (140, 142)
recreation 21 (133)
plant analysis 50 (168, 169)
development 51, 503 (170, 1074)
ecology 50-53, 58 (168-173, 178)
growth inhibitors 3 (195)
physiology 500, 503 (1071, 1074)
plant-soil-animal relations 15, 53, 57, 59 (171, 177, 179, 316, 317)
plant succession 413 (994)
plantations 257, 258, 346 (10, 408, 437)
planting, 456, 464, 465, 467, 474 (1023, 1032, 1033, 1035, 1044)
hardwood 466 (1034)
seed 52, 61 (172, 173, 181)
planting hardwoods 471 (1040, 1041)
plants, Alpine 58 (178)
forage 51, 58, 59 (170, 178, 179)
indicator 416 (997)
medicinal 62 (965)
woody 540 (1115)
plastochron index 503 (1074)
plywood, 567, 609, 622, 628 (44-47, 59, 816, 924)
hardwood 625 (54)
southern pine 335 (117, 122, 126)
plywood production 355 (23)
resins 587 (840)
pocket gophers 488 (1058)
podocarpus, Java 475 (1045)
pole blight 319 (550)
pollen storage 558 (1134)
pollination, 558 (1134)
insect 279 (469, 471, 474)
pollution, 351, 596, 599 (16, 891, 894, 898, 899)
air 295, 296, 298, 431, 598 (398, 490, 493, 494, 902)
pollution control 588 (846)
poplar, 295, 548 (490, 1126)
balsam 403 (983)
hybrid 474 (1044)
Populus 547 (1123)
porcupines 12 (309)
Poria root rot 245-247, 254 (415, 422, 435, 436, 440)
posts, 623 (50)
wood 595 (831)
prairie crayfish 458 (1025, 1026)
precipitation 377 (258)
effectiveness index 434 (406)
predation 121 (606)
predators, 115, 127, 180, 182, 184 (588, 620, 685, 697, 703)
seed 458 (1025, 1026)
predictive models 40, 41, 43-46, 49 (154, 155, 157, 159-163, 166)
prescribed burning 450, 452, 454 (1017, 1019, 1021)
burns 75 (336)
prescription fires 74 (327-329, 337, 340, 344)
preservative dip treatment 304 (511, 518)
preservatives, 623 (50)
wood 304, 575 (511, 518, 834)
prevention, fire 68 (326)
prevention techniques 69 (330)
prices, 619, 628 (29, 44-47)
pulpwood, South 333 (105, 120)
stumpage 355 (23)
probability model 435 (402)
productivity 353 (24)
programming, linear 342, 343 (3, 17)
programs, assistance 352 (26)
Project Aero-Fire 78 (347)
Project Skyfire 78 (347)
protein metabolism 500 (1071)
pulp 596, 602 (894, 906)
pulp chips 359 (784)
pulping 594, 604 (891, 898, 899, 907-909)
pulpwood, 601, 628 (44-47, 886, 887, 903, 904)
North Central 332 (107)
Northeast 331 (114)
South 330 (104, 106)
pulpwood prices, South 333 (105, 120)
pumice soils 497 (1068)
pump-manometer 387 (302)
Pyemotes parviscolyti 174 (698)
pyrethrin 199 (727)
pyrethrins 203-205, 217, 218 (715, 716, 718, 719, 724)
pyrolysis, 104 (380)
isothermal 102 (367)
Pythium root rot 254, 259, 260 (411, 412, 440)

quail 17 (319)
Quercus 558 (1134)

racial variation 551 (1120)
radiation, soil water 372 (239)
solar 386, 416 (307, 997)
radioactive tracer 162 (658)
radiography 227 (743)
rainfall 372 (239)
range, cutover forest 54 (167, 174)
range management 7-9, 14, 52, 53, 55-57, 59-61 (171-173, 175-177, 179-181, 310, 312, 315, 318)
range surveys 50 (168, 169)
ranges, 9, 57, 59 (177, 179, 315)
browse 7 (310)
forest 55, 56, 60 (175, 176, 180)
recreation, 21-25, 44, 48, 375 (133, 134, 137-139, 161, 165, 253)
forest 18, 30-38, 43, 47 (144-152, 157, 158, 164)
recreation capacity 38 (152)
demand 34-36 (148-150)
facilities 32 (146)
site management 413 (994)
site pathology 318 (552)
sites 18, 33, 35-39, 318 (147, 149-153, 164, 552)
use 34 (148)
recreational capacity 39 (153)
use 44 (161)
use, forest 40, 41, 45, 46, 49 (154, 155, 159, l60, 162, 163, 166)
recycling 596 (894)
redcedar, western 417, 511 (998, 1083)
reforestation, 475 (1045)
burned area 403 (983)
regeneration, 275, 412, 482 (455, 993, 1052)
artificial 455-475, 488, 491, 497, 531, 556 (1022-1045, 1058, 1061, 1068, 1104, 1132)
natural 388-404, 406, 409, 493 (968-984, 987, 990, 1063, 1064)
regressions, linear 149 (595)
regulation, forest 342, 343, 349 (3, 17, 18)
rehabilitation 37, 38 (151, 152)
release 486 (1056)
remote sensing 247, 420-423, 426 (387-391, 394, 395, 397, 435, 436)
remote-sensing habitats 50 (168, 169)
removals, timber 326 (87, 92, 94, 102, 103)
repellency, water 370 (221, 232)
repellents 489-491 (1059-1061)
reproduction, vegetative 403 (983)
residues 329, 564 (113, 115, 116, 789)
resin 537 (1111)
acids 598 (902)
adhesives 587 (840)
resins 600 (896, 897, 911, 913)
resistance, decay 308 (504)
genetic 263, 265, 270, 295 (442, 461, 463, 490)
host 222 (741)
resistance mechanisms, natural 264 (453)
resource appraisal 338 (131)
management 94 (382)
respiration, root 494 (1065)
retardant delivery systems 84 (348)
effect 88 (358)
product 87 (346)
utilization 89 (355)
retardants, 85, 86 (353, 354)
salt content 85 (353)
return periods 365 (212)
road building 381 (281)
standards 357 (770)
roads, 348 (13)
forest 357 (770)

roads - - continued
logging 373, 378 (215, 270)
rodents 492 (1062)
root chemicals 256 (424, 433, 434)
pathogens 250 (425)
protection 251, 254, 255 (416, 423, 432, 438-440)
pruning 317 (564)
respiration 494 (1065)
rooting 559 (1135-1137)
roots 448, 501 (1015, 1072)
Roptrocerus xylophagorum 180 (697)
rot, root, annosus 242-244, 254 (409, 413, 426, 427, 440)
root, Armillaria 256, 257 (424, 433, 434, 437)
root, Ganoderma 313 (519, 530)
root, Phytophthora 254, 260-261 (412, 414, 431, 440)
root, Poria 245-247, 254 (415, 422, 435, 436, 440)
root, Pythium 254, 259, 260 (411, 412, 440)
root and butt, Peniophora 258 (408)
runoff 364, 376, 377, 380 (234, 258, 265, 278)
reduction 1 (184)
rural employment 616 (36)
rust, blister, white pine 263-267 (442, 447-450, 453, 456, 458, 463)
comandra 272 (460)
cone, southern 216 (711)
eastern gall 268, 269 (445, 459)
fusiform 268-271, 541, 553-555, 557 (444, 445, 459, 461, 1122, 1129-1131, 1133)
southern cone 324 (540)
rust infection hazard 271 (444)
resistance 270, 272 (460, 461)
spore production 267 (456)
susceptibility 268 (445)

safety, chemical 5 (207)
sage, creeping 72 (334)
sagebrush, big 9 (315)
salicylic acid 392 (972)
saline water 3 (195)
Salix 556 (1132)
salmonberry 479 (1049)
salt content, retardants 85 (353)
saltbush, fourwing 73 (335)
sampling, 525 (1097)
insect 228, 229 (748, 753)
litter 110 (383)
sap production 533 (1105)
Saperda inornata 142 (623, 624)
Saratoga spittlebug 125, 126, 209 (607, 649, 732)
sawfly, European pine 187, 229 (691, 753)
western hemlock 122 (602)
sawing systems 573 (792, 957)
sawlog production, Kansas and Iowa 334 (111, 112)
sawmilling 572, 573 (792, 798, 957)
saws 572 (798)
scale, tuliptree 127 (588)
scale insects 128 (580)
scaling, log 522 (1094)
scenic values 25, 26, 28, 408 (139, 140, 142, 989)
Scolopscelis mississippensis 180 (697)
seasoning 562, 580 (812, 875)
sediment reduction 1 (184)
removal 385 (290)
sources 378 (270)
transport 378 (270)
yields 378, 380 (270, 278)
sedimentation 364, 381, 382 (234, 281, 286)
seed, 496 (1067)
hardwood 312 (523)
seed and cone insects 129, 131, 132, 134, 135, 215 (574, 585, 586, 615, 652, 654, 723)
and cone production 400, 493 (980, 1063, 1064)
dispersal 283, 388 (472, 968)
germination 52, 61 (172, 173, 181)
maturity 496 (1067)
orchard 324 (540)
orchard insects 169 (665)
orchards 453 (1020)
planting 52, 61 (172, 173, 181)
predators 458 (1025, 1026)
processing 390 (970)
production 132, 388, 391, 402-404 (585, 968, 971, 982-984)
source zones 551 (1120)
storage 394, 455 (974, 1022)
seedbed requirement 403 (983)
seeding, aerial 4 (196)
direct 458-460, 463, 468, 471, 473, 490, 491 (1025-1028, 1031, 1036, 1037, 1040, 1041, 1043, 1060, 1061)
seedling development 497 (1068)
growth 504 (1075)
seedlings 317 (564)
seeds, 389, 395 (969, 975)
chemical properties 389 (969)
seedworms 133 (591)
selection, 531, 553 (1104, 1129)
group 531 (1104)
selective thinning 478 (1048)
selfing 544 (1125)
Septoria canker 277 (446)
Serratia marcescens 186 (696)
sex attractant 108 (657)
shade tree diseases 315 (543)
shakes 577 (838)
sheathing siding 609 (924)
sheathminer, pine needle 120 (638)
shelterbelts 65, 66, 151 (637, 963, 964)
shelterwood 531 (1104)
shingles, wood 577 (838)
shoot blight, Diplodia 293 (483)
shoot borers 124 (617)
Siberian larch 65 (964)
siding 609 (924)
silage-sycamore 346 (10)
silvicides 5 (207)
silvics 527 (1099)
silvicultural control 219-221, 240, 241, 284 (473, 733-735, 756, 757)
methods 401, 405-411 (981, 985-992)
systems 399 (979)
silviculture 527 (1099)
Sirococcus tip blight 316 (562)
sissoo 313 (519, 530)
site evaluation and soil improvement 436-454 (1002-1021)
factors 223 (738)
index 336, 415, 438, 439, 441, 445 (127, 996, 1004-1006, 1008, 1012)
index curves 438, 441, 442, 444, 451 (1004, 1005, 1008, 1009, 1011, 1018)
preparation 393, 459, 464 (973, 1027, 1032)
skidders, wheeled 360 (776)
Skyfire, Project 78 (347)
skyline logging 361 (766)
slash burning 431 (398)
fuels 105 (369)
pine yields 528 (1100, 1101)
slash x shortleaf hybrid 541 (1122)
small game 16 (320)
smaller European elm bark beetle 157, 158, 206, 207 (667, 672, 706, 707)
smoke, production and dispersion 95 (364)
smoke dispersion potential 431 (398)
snow fences 374 (267)
snowmelt 367, 373 (215, 220)
snowpack 372, 377 (239, 258)
management 374 (267)
sites, recreation 18, 33, 35-39 (147, 149-153, 164)
softwoods, 616 (36)
northern 442 (1009)
soil chemistry 448 (1015)
compaction 414, 440 (995, 1007)
erosion 381 (281)
flooding 440 (1007)
genesis 437 (1003)
herbicide 483 (1053)
mass movement 381 (281)
mesofauna 450 (1017)
microbiology 4 (196)
moisture 412, 443 (993, 1010)
nutrients 437, 440, 446 (1003, 1007, 1013)
physical properties 452 (1019)
soil-plant-animal relations 15, 53, 57, 59 (171, 177, 179, 316, 317)
soil site 440 (1007)
slippage 2 (194)
texture 379 (282)
toxins 255 (438)
type 448 (1015)
water radiation 372 (239)
soils, forest 371 (210)
hydrophobic 370 (221, 232)
solar radiation 386, 416 (307, 997)
solid waste utilization 3 (195)
solid wastes 596 (894)

sound absorption 6 (208, 209)
southern cone rust 216, 324 (540, 711)
hardwoods 395, 440, 482 (975, 1007, 1052)
pine 569, 590 (811, 845)
pine bark 584, 588 (839, 846)
pine beetle 115, 116, 172, 180, 186, 223 (603, 620, 668, 696, 697, 738)
pine properties 611 (917)
spacing 467, 516, 528 (1035, 1088, 1100, 1101)
spanworm, elm 163 (663)
species adaptibility 475 (1045)
composition 482 (1052)
introduction 481 (1051)
specific gravity 136, 542, 592, 606 (577, 818, 938, 1117)
spittlebug, Saratoga 125, 126, 209 (607, 649, 732)
spoil vegetation 379 (282)
spore production, rust 267 (456)
trapping 290 (485)
spraying, aerial 197, 198 (720-722)
sprouting, 401 (981)
epicormic 510 (1082)
sprouts, 398 (978)
stump 395 (975)
spruce, black 403, 523 (983, 1095)
Engelmann 299, 405, 457 (495, 985, 986, 1024)
Norway 546 (1118, 1119)
Sitka 407, 417 (988, 998)
white 403, 404 (983, 984)
spruce budworm 161, 164, 176, 195, 196, 200, 218 (655, 676, 695, 719, 725, 728, 731)
budworm, western 166 (677)
spruce-fir forests 461 (1029)
squirrels 16, 492 (320, 1062)
stain 138 (634)
stain and decay control 302 (500, 501, 512)
stand density 519 (1091)
improvement 476-487, 490 (1046-1057, 1060)
staves 139 (579)
steam bending 589 (848)
steep terrain 2 (194)
sterols 155 (682)
stimulant, feeding 155 (682)
stocking 519, 534 (1091, 1107)
levels 514 (1086)
storage, chip 601 (886, 887, 903, 904)
stream improvement 382 (286)
streamflow 363, 364, 368 (226, 234, 237)
forecasts 377 (258)
streams 45 (160)
strength properties 611 (917)
strip mine reclamation 1 (184)
structural members 606 (938)
structures 608 (945)
studs 585 (842, 843)
stump sprouts 395 (975)
stumpage prices 355 (23)
subalpine meadows 413 (994)
subsurface water movement 371 (210)
succession, forest 419 (1001)
succession of microorganisms 307 (515)
sulfur dioxide 295, 296 (490, 494)
supply, timber 325, 352 (26, 99, 100)
survey, forest 326, 327, 338 (87, 92-94, 102, 103, 131)
survey methods, insect 230, 231, (749, 750)
methods, land 232-237 (742, 744-747, 751)
surveys, range 50 (168, 169)
sweet-fern 125, 126 (607, 649)
sweetgum 249, 480, 484, 545 (410, 428, 429, 1050, 1054, 1127)
sycamore, 568 (808)
American 249, 274 (410, 428, 429, 462)
silage 346 (10)
systemic insecticides 209, 210 (730, 732)
systems, harvesting 358 (767)

tall oil 600 (896, 897, 911, 913)
taxes, income 348 (13)
taxonomy, 278, 547 (466, 1123)
pine 538 (1112)
temik 209 (732)
temperature, 372, 416 (239, 997)
potential 430 (399)
water 383 (291)
temperature effect on fungal growth 273 (454)
efficiency index 434 (406)
tepa 161 (655)
termite, eastern subterranean 136 (577)
Formosan 212 (709)
subterranean 214 (714)
termites, 137 (632)
subterranean 211, 212 (708, 709)
terpenes 173 (684)
terrain, steep 2 (194)
Thanasimus dubius 180 (697)
thermobalance measurements 102 (367)
thermograms 103 (379)
thimbleberry 479 (1049)
thinning, 410, 509, 516, 568, (808, 991, 1080, 1081, 1088)
precommercial 514 (1086)
selective 478 (1048)
thrips 131, 216 (586, 711)
timber bridges 613 (941)
evaluation 591 (836)
growing 350 (19)
growth 326 (87, 92, 94, 102, 103)
management 527, 529, 530 (1099, 1102, 1103)
product potential 591 (836)
quality 566 (803)
removals 326 (87, 92, 94, 102, 103)
supply 325, 352 (26, 99, 100)
volume 326, 327 (87, 92-94, 102, 103)
timbers, 623 (50)
laminated 593 (854)
tip moth, Nantucket pine 134, 153 (651, 652, 654)
tissue culture 266, 323 (447-450, 458, 538, 547, 549, 565-571)
topography 372 (239)
tornado models 107 (375)
tortrix, orange 199 (727)
town ant 150, 170 (619, 683)
toxicology 194 (712)
toxins, soil 255 (438)
tracer, radioactive 162 (658)
transpiration 287 (475, 476)
tree breeding 541 (1122)
breeding methodology 558-560 (1134-1138)
genetics 536, 550 (1110, 1124)
grades 563, 570 (794, 812)
growth 438 (1004, 1005)
harvesting, mechanical 461 (1029)
identification 540 (1115)
improvement 552, 559 (1128, 1135-1137)
physiology 224 (737)
shears 590 (845)
treefern 515 (1087)
trenching, contour 369 (217)
trichlorfon 202 (717)
Trichoderma spp. 246 (422)
tuberculate mycorrhizae 254 (440)
tuliptree scale 127 (588)
turpentining 358 (767)
tussock moth 193 (689)
2, 4-D 288 (481, 482)
type conversion 344 (8)

updating system 328 (88)
upland hardwoods 409 (990)
oaks 471 (1040, 1041)
urban watersheds 366 (231)
use, recreational 18, 34, 39-41, 44-46, 49 (148, 153-155, 159-164, 166)
user attitude 23, 24 (137, 138)
characteristics 23, 46 (137, 159, 162, 163)
users 30, 31, 43, 47, 49 (144, 145, 157, 158, 166)
utilization, 329, 482 (113, 115, 116, 1052)
retardant 89 (355)
solid waste 3 (195)

value, present 340 (2)
value growth 345 (9)
values, 29, 47 (143, 158)
scenic 25, 26, 28, 408 (139, 140, 142, 989)
variation, see inherent variation
vascular water flow 287 (475, 476)
vegetation, herbaceous 81 (352)
spoil bank 379 (282)
vegetation types 539 (1113)
vegetative changes 380 (278)
propagation 470, 472 (1039, 1042)
reproduction 403 (983)
veneer, 616 (36)
hardwood 335 (117, 122, 126)

veneer grades 567 (816)
recovery 567 (816)
yields 567 (816)
Verticillium wilt 286 (477, 479, 480)
viruses 187 (691)
volume, 524 (1096)
timber 326, 327 (87, 92-94, 102, 103)
volume tables 518 (1090)
vortex types 107 (375)

walnut, black 443, 466, 471 (1010, 1034, 1040, 1041)
walnut dimension 581 (829, 872)
waste, solid, utilization 3 (195)
waste disposal 615, 617, 618 (27, 28, 31)
paper 596 (894)
water, ground 351 (16)
saline 3 (195)
water damage 578 (871)
movement, subsurface 371 (210)
quality 382-385 (286, 287, 290, 291)
relations 366 (231)
repellency 370 (221, 232)
table depth 417 (998)
temperature 383 (291)
yield 363-370, 375 (212, 217, 220, 221, 226, 231, 232, 234, 237, 253)
yield improvement 374 (267)
watershed rehabilitation 379 (282)
watersheds, 350, 351 (16, 19)
municipal 395 (253)
urban 366 (231)
wax moth 167 (656)
weather forecasting 271 (444)
systems 433 (407)
weed control 466 (1034)
weevil, pales 145, 146, 154-156, 210 (636, 641, 669, 681, 682, 730)
pecan 130 (589)
pine root-collar 147 (608)
pitch eating 145 (636)
weight scaling 569 (811)
western hemlock looper 177 (704)
hemlock sawfly 122 (602)
pine beetle 171, 172, 205 (660, 668, 715)
pine tip moth 208 (729)
spruce budworm 166 (677)
wheeled skidders 360 (776)
white grubs 144 (594)
pine blister rust 263-267 (442, 447-450, 453, 456, 458, 463)
wilderness areas 19-24, 46 (132-138, 159, 162, 163)
fire study 91 (345)
wildfire, Montana forests 95 (364)
wildfire statistics, Alaska 93 (362)
wildfires, 432 (403)
Georgia 83 (359)
wildlife food plants 8, 9, 13, 15, 17, 52 (172, 173, 312, 313, 315-317, 319)
management 7-16 (309-318, 320)
willow, black 556 (1132)
weeping 494 (1065)
wilt, oak 286-289 (475-482)
Verticillium 286 (477, 479, 480)
wind 386 (307)
windbreaks 64, 65 (964, 966)
windfall risk 405 (985, 986)
winds 432 (403)
wood adhesion 587, 593 (840, 854)
base panels 612 (937)
bonds 587 (840)
chemistry 599-601 (886, 887, 891, 896-899, 903, 904, 911, 913)
chips 359 (784)
conversion 614 (953, 955, 956)
decay 301, 304-308, 310 (502-504, 506, 507, 509-511, 515-518)
decay control 303 (497)
decay in ships 309 (505)
decay prevention 303 (497)
decks 610 (915)
demand 623 (50)
density 561 (812)
deterioration 601 (886, 887, 903, 904)
discoloration 305-307 (506, 507, 515-517)
drying 562, 585 (812, 842, 843)
durability, in ships 309 (505)
extractives 592 (818)
fertilization 561 (812)
fiber products 602, 604 (906-909)
guardrails 595 (831)
harvesting 564 (789)
laminated 613 (941)
machining 582, 583, 586 (852, 868, 870)
moisture 576 (862)
moisture content 569 (811)
planing 583 (870)
posts 595 (831)
preservation 575, 623 (50, 834)
preservatives 304, 575 (511, 518, 834)
processing 629 (48)
properties 611 (917)
protection 577 (838)
pulp 596, 602 (894, 906)
quality 542, 545, 561, 563, 570, 576, 591 (794, 812, 836, 862, 1117, 1127)
residues 597, 614, 615, 619, 621 (27, 29, 35, 890, 953, 955, 956)
wood-rotting fungi 300, 301 (496, 509, 510)
wood shingles 577 (838)
treatments 575 (834)
wood-using industry 615 (27)
wood utilization 564 (789)
woodlot management 469 (1038)
woodpeckers 180, 184 (697, 703)
woodpulp 604 (907-909)
woodwork, exterior 304 (511, 518)
woody material 100 (368)
plants 540 (1115)
xylan 103 (379)
xylem formation 507 (1078)

yellow-poplar 127, 249, 390, 436, 448, 471, 494 (410, 428, 429, 588, 970, 1002, 1015, 1040, 1041, 1065)
yield tables 523, 524, 529, 530 (1095, 1096, 1102, 1103)
yields, slash pine 528 (1100, 1101)

Zectran 195, 199-201, 205 (715, 726-728, 731)